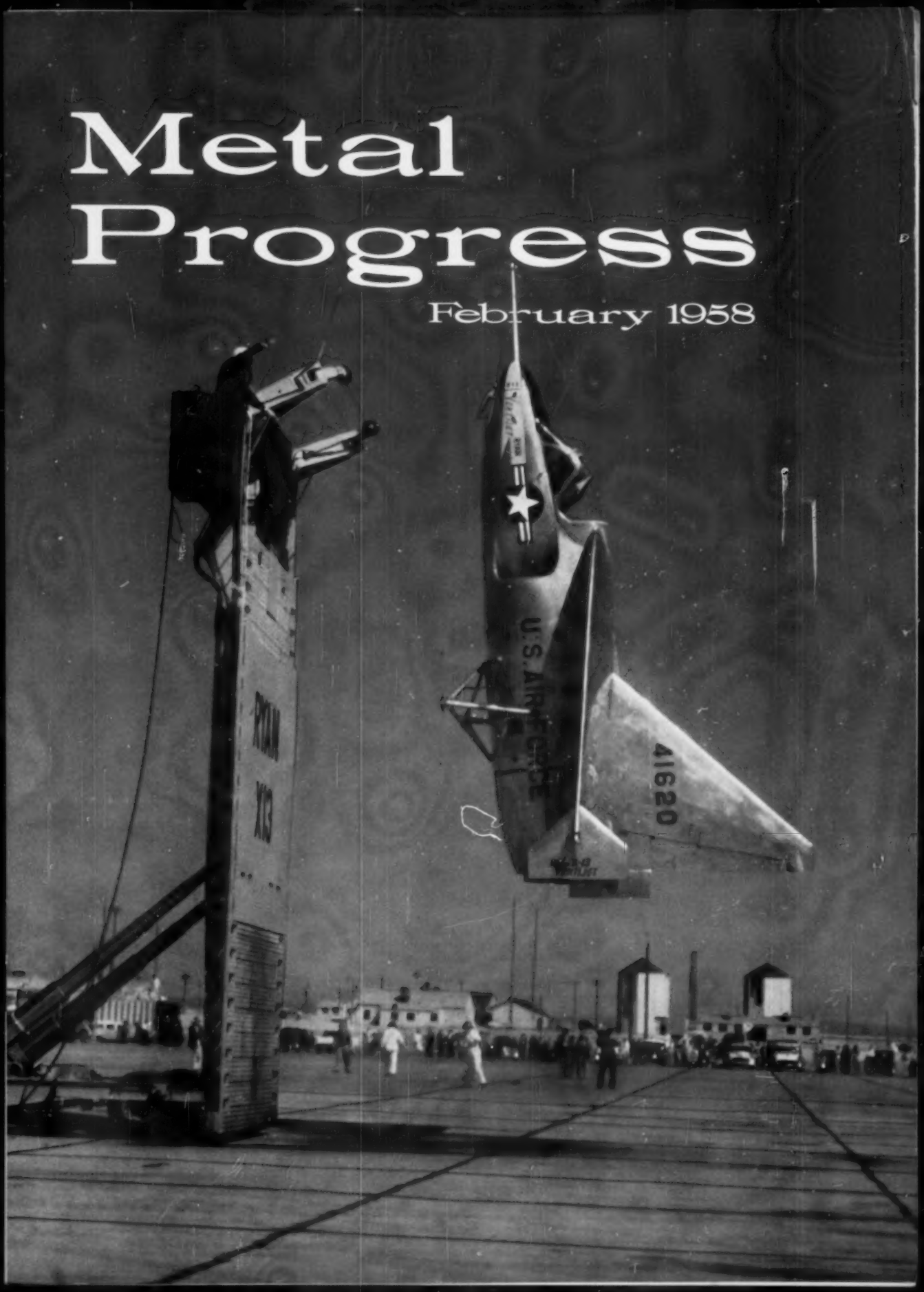
Metal Progress

February 1958



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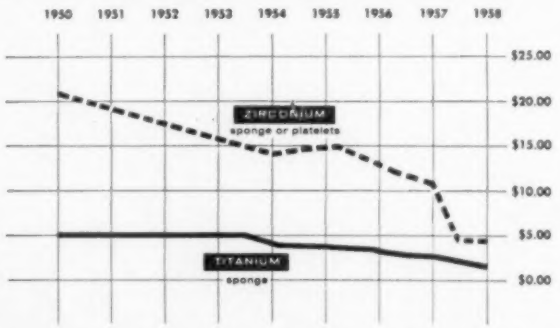

Regular price reductions in titanium and zirconium sponge have also been reflected in lower prices for mill products. This trend shows the wisdom of evaluating titanium and zirconium now for your new products.

MALLORY-SHARON

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Metal Progress

Volume 73, No. 2

February . . . 1958

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Cover photograph shows Ryan X-13 Vertijet, subject of the lead article in this issue.

Vertical Take-Off and Landing, by Lawrence J. Hull 68

Thrust from a powerful jet engine gives vertical take-off; control of direction is by slight changes in the direction of the main exhaust, and stability against roll is by jet reaction controls, all electrically interlinked at the pilot's fingertips. (T24, 17-57)*

Automation in Heating and Quenching, by Norbert K. Koebel 72

Whether the part in mass production be a knitting needle, a gear or a ship plate, automatic line-ups of heat treating equipment can deliver a steady stream of product of superior uniformity meeting strict specifications for dimension, surface, and strength. (J general, W27, 18-74)

Heating at High Speed, by Norman H. Davies and Richard J. Reed 79

High-speed heating of metal requires both convection and radiation from furnace gases and walls considerably hotter than finishing temperature. Consequently fast controls are necessary to prevent overheating the work if the production line slows down. (F21b, W20h, P11k)

Modernization in Heating for Hot Forming, by Philip W. Morse 85

Sixty-cycle three-phase current can economically heat billets for forging, upsetting or extrusion. After the magnetic change point is passed, 960-cycle coils – dual purpose – carry the temperature higher. Higher frequencies are used for smaller billets. Several completely automatic systems are described. (F21b, W28s; ST, Mg, 4-52)

Damage by Uncontrolled Shot Blasting, by Konrad Kornfeld 92

Shot blasting, used for cleaning, should be subjected to the same control as shot peening used to improve fatigue resistance. (L10)

Salaries of Metallurgists, by Walter Morrison 93

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Investment Casting of Precious Metal Jewelry, by Ralph H. Atkinson 97

Although basic principles are the same as in casting other metals, melting and casting methods for platinum, palladium, silver and gold vary considerably from those used in producing turbine buckets and machine parts. (E15, Tgs, 17-57; Pt, Pd, Au, Ag)

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METAL PROGRESS is published monthly by the AMERICAN SOCIETY FOR METALS. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $3.00 . . . The A.S.M. is not responsible for statements or opinions in this publication.

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"Fatigue in Aircraft Structures", edited by A. M. Freudenthal, is a collection of papers presented at a three-day international conference in early 1956 at Columbia University. Representing the experiences of specialists throughout the free world, it presents many views for the reader to ponder and take his choice.

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As I was saying...

I AM ENJOYING a holiday on the Great American Desert, and as I bask in the glorious sunshine of this tropical oasis of Palm Springs my eyes eagerly seek the weather report to learn the temp in dear old Cleveland, where the rest of the 89 "Guys and Dolls" in the ⊕ family are fighting snow drifts and northern squalls. I feel sorry for them but not too much so because I'll soon be back with them fighting and moving the snow-white crystals.

"Miss Friday" back in the office keeps me informed, per example:

"Dear Boss: You've been gone almost two weeks, and so much has happened I hardly know where to start. We had a fine Christmas party. About 85 came to headquarters for the buffet luncheon. It was then I realized that the A.S.M. family is distributed in five buildings all over Cleveland. So many of the girls looked like strangers that the main words of conversation were 'Do you work for A.S.M.?' They were all goodlooking and on their toes. Too bad you missed that party.

"Mr. Bayless told me he has sent to the printer all the copy for the *Transactions*, the Seminar Book, and the new Chapter Speakers' Directory (to be sent to the chapters in a couple of months for use in planning next year's programs).

"Mr. Thum finally 'Simon Legreed' the January International issue of *Metal Progress* out of Cleveland through Mt. Morris to the members, only a few days late. It was a fine issue. When he learned that the printer of M.P. is also the printer for a magazine called *Confidential* he worried that the *Confidential* cover might accidentally land on M.P.!

"Dr. Lyman reports they are now doing the last group of committees for the first volume of the new issue of the Handbook. He expects to have the committee work finished by July—and then six months for production.

"The Air Materiel Command project is going full steam ahead and committee organizational work is on the move and receiving cordial cooperation from the airframe industries.

"Mr. Wells is busy with the Dallas and the Cleveland Shows. The Dallas Show (May 12 to 16, 1958) is just about sold out, while the contracts and reservations are rolling in at a merry clip for the Cleveland Show (Oct. 27 to 31).

"The *Transactions* order form was mailed to all members on Jan. 3 and orders are already coming in.

"Mr. Ford gave me the M.P. year-end advertising report and it showed the largest number of pages in the history of this publication. I told him I knew you would be mighty happy with the work the advertising men had accomplished. (*Turn to p. 6*)

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As I was saying...

"Ted Du Mond is getting along marvelously with the program for the Southwestern Metal Congress and the Billy Woodside Memorial Panel Sessions the National Metal Congress in Cleveland this fall. He told me the editorial work for M.E.I. is making splendid progress and the ten additional courses will be ready on time.

"Dr. Brasunas is really getting a taste of being busy because the M.E.I. is still going like a house-afire. The first student is about to complete his course and the first in-plant training group at Cleveland Pneumatic Tool Co. is about to graduate. Dayton, Rochester and Worcester have inquired about presenting M.E.I. courses.

"The Los Angeles chapter, with its class of 94 in two divisions, has aroused the interest of other chapters. John Wilson (chairman of Los Angeles) sure gave a fine presentation of M.E.I. at the Chapter Chairmen's Breakfast at Chicago. You should give him a cigar.

"Adolph Buehler sent another check for $2000 (same as last year). He wrote that it is to provide more bricks or concrete or steel for the new headquarters. That makes $5500 that has been contributed toward the new building—$4000 from Mr. Buehler, $500 from 'a friend', and $1000 from the Chicago-Western chapter.

"Do have a good time, and don't worry about 7301 or 7335 or 4600 Euclid or E. 105th St. or the office on Kinsman.

"If you see Cary Grant or Clark Gable tell them the girls at the office send their love—and if you see Bing Crosby remind him to look around to answer his son Gary's wish, 'I want a girl just like the girl who married dear old Dad'.

"Bye now—Evelyn"

With the above chores I'll be as busy out here as if I were home. However, it is comforting to me way out here to know the ⊕ staff is the kind of a staff that provides me a staff on which to lean and it gives me such great satisfaction to realize that over the years I've assembled this group one by one, and I would not trade this staff for all the gold in the world.

Cordially,

Bill

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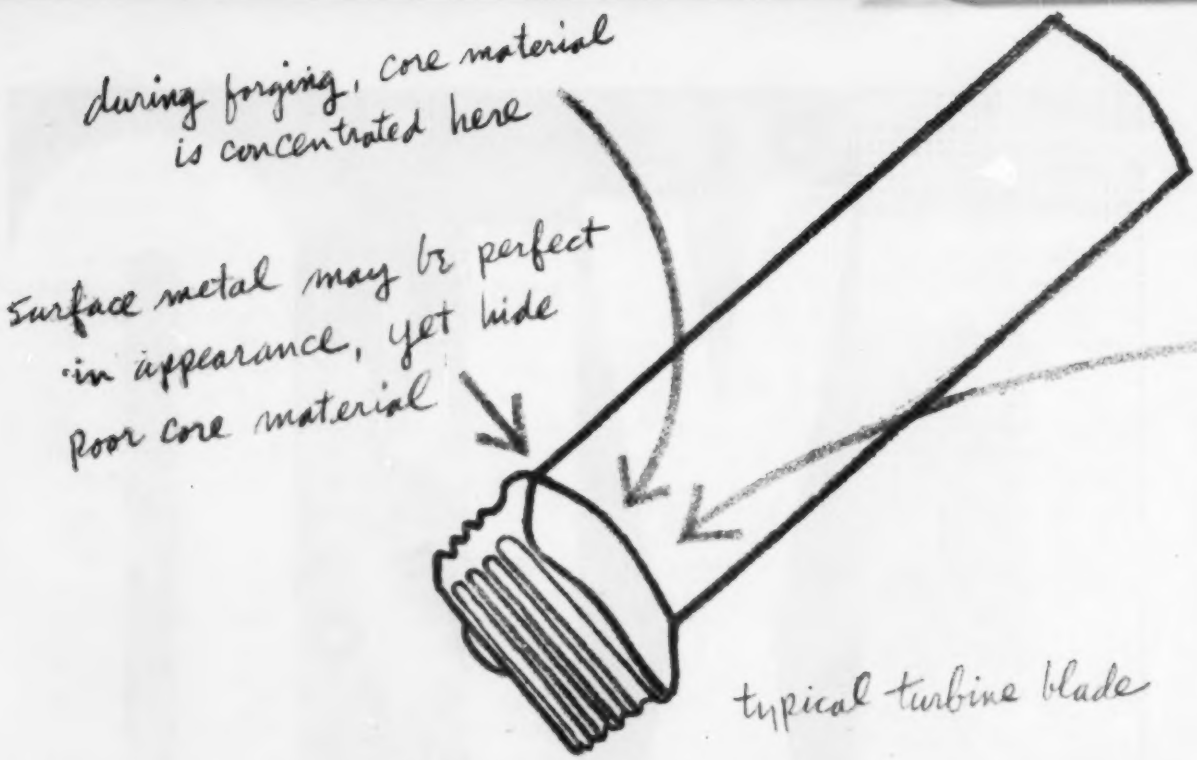
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strength critical here, because stress concentrates here. Any centerline weakness may cause cracks in forging or eventual failure in service. Mel-Trol alloys provide more uniform strength and greater freedom from segregation, ideal for applications like this because Mel-Trol process assures toughness at the core of the alloy.

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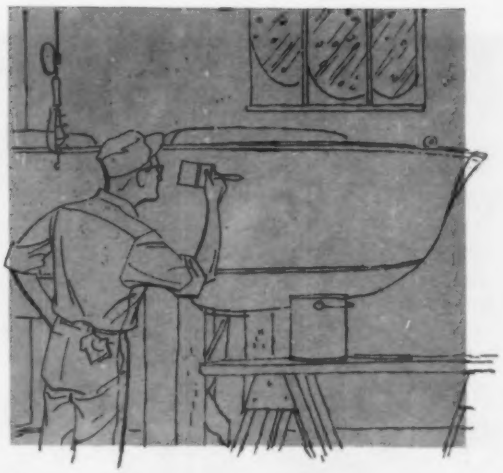

1 Bill Lewis, service engineer at Honeywell's Fort Wayne branch, was in his garage, touching up the paint on his 13-foot outboard. The bowling match had been called off that night because of the snowstorm, and Bill was glad to be home.

2 At 9:30 a call came from the Crosby Laughlin Division of American Hoist and Derrick Company in Fort Wayne. A controller on a galvanizing kettle wasn't working and unless it was fixed fast, the pot would either freeze or burn out. Bill said he would be out right away.

4 Bill didn't have a thermocouple with him that would fit, so he improvised a temporary couple and protecting tube and got the system going. Early the next morning he called the Honeywell branch in Indianapolis and had the correct thermocouple and tube shipped quickly to the plant. Next day, he carefully checked out the entire installation.

5 Now, Crosby Laughlin Division is signed up with the Honeywell Periodic Service Plan, and its complete instrumentation is checked and serviced every month. Any spare parts needed are now available at Honeywell's Fort Wayne branch. Bill hasn't had to make another emergency call to the plant since.

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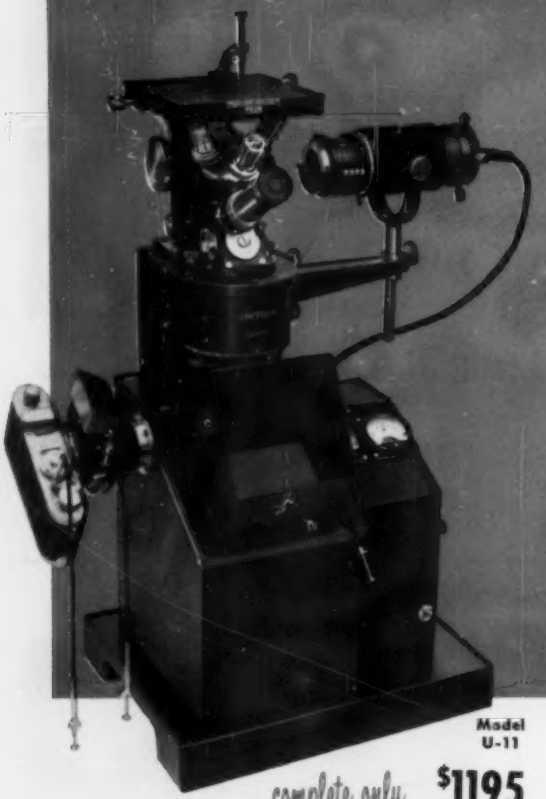

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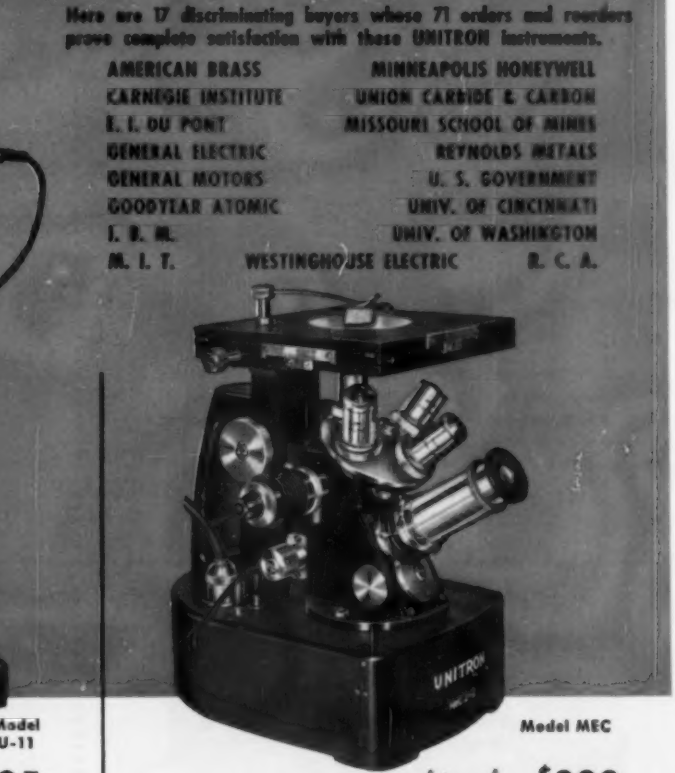

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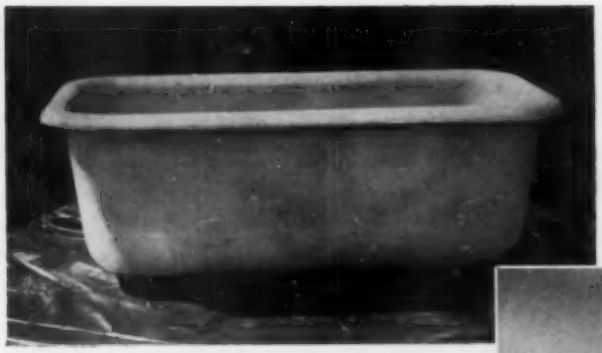
Address _____

City _____ State _____



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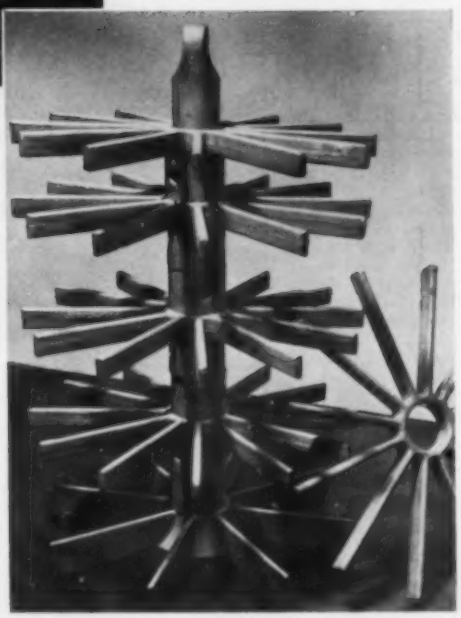

or Fancy

HEAT AND CORROSION RESISTANT CASTINGS THAT IS...

. . . there is something about the name ACCOLOY you should know. Every alloy application, whether it be a cyanide pot or the tree fixture shown above, must be engineered for the job. The improved design of castings, the finer grain size, the close control of pouring and the multiple testing of the finished job are all points of superiority that so many manufacturers demand AND GET when they use ACCOLOY castings. They pay off equally well in extending fatigue life and lowering your cost per heat hour in either simple or complex designs.

Call your nearest ACCOLOY ENGINEER for an honest analysis of your high temperature problems.

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ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

MOLY NEWS

CLIMAX MOLYBDENUM, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

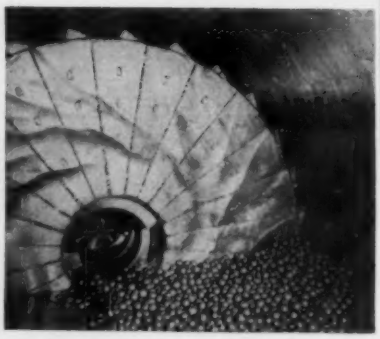
Chrome-Moly Steels Prove Ability To Resist Wear and Abrasion, Cut Costs

Can be Adapted to a Wide Range of Uses

To offset rising equipment and maintenance costs, the savings possible with wear-resistant alloy steels are receiving increasingly wide attention, in a growing number of industries.

Two types of "Chrome-Moly" steels show exceptional resistance to abrasion and wear under toughest conditions. Both have substantially cut liner costs and shutdown time in grinding mills. Both are suitable for a variety of other industrial applications because they combine wear resistance, favorable first cost, freedom from premature failure by breakage or spalling, resistance to flow in service, consistently uniform performance and adaptability to specific designs.

The two types are Pearlitic (250-450 BHN) and Martensitic (450-700 BHN). Carbon and alloy contents and heat treatments of both types can be varied to suit specific applications.



Note that the spiral wear pattern is clockwise, even though the mill's rotation is counterclockwise. Type 2 Martensitic steel is used here.

For an article on the use of Chrome-Moly steels, send for "How to Select Chrome-Moly Steels for Ball and Rod Mill Liners" by T. E. Norman, reprinted from Engineering and Mining Journal. Circle #1 on the coupon.

New Use For Super-Strength Structural Steels

Today, gasoline trailer tanks are built of super-strength structural steels for a good reason. The steels have high strength/weight ratios. This factor enables builders to design tanks that carry greater payloads and still meet legal gross weight limits. And the extra capacity pays for the higher trailer cost in a few months!

This use is only one of countless possibilities for utilizing the steels' minimum yield strengths of 55,000 to 150,000 psi . . . and their many other desirable properties. *For more information, including tradenames and compositions, ask for "Super-Strength Structural Steels." Circle #2.*

Sums Up Moly's Resistance to Corrosion

A new paper, "Corrosion Resistance of Molybdenum and Molybdenum-Base Alloys," based on published literature, summarizes moly's resistance to a number of corrosive media. It also lists the reference articles. For a copy of this paper, *circle #6.*

Molybdenum Improves Corrosion Resistance of Stainless Steels

Translated excerpts from two French articles discussing how moly improves the corrosion resistance of austenitic and austenitic-ferritic stainless steels are now available. *Circle #7.*

Special Steels Solve Hydrogen Sulphide Problem

Hydrogen sulphide in France's Lacq natural gas field brought up a metallurgical problem: the need for tubing meeting the N-80 strength requirements but with better resistance to sulphide stress corrosion than the conventional N-80 grade. Two such steels have been developed. One contains chromium, aluminum and molybdenum; the other contains chromium, molybdenum and vanadium.

For articles discussing both steels, send for "A Special N-80 Steel Tubing . . . " by Cauchois, Didier and Herzog, reprinted from *Corrosion*, and "Comments on new French N-80 Steels" published by Climax. *Circle #3.*

Vanadium in Low-Alloy, High-Temperature Steels

Molybdenum is a must in low-alloy, high-temperature steels. However, recent tests at the U.S. Naval Research Laboratory point up the role of Vanadium in such steels, and show the effect of variations in composition and treatment. Addition of Vanadium results in a better high-temperature alloy, but getting the improvement requires higher normalizing temperatures.

The advantages and limitations are described in an *Iron Age article*, "Higher Vanadium Improves Hot Strength of Low Alloy Steel," by Paul Shahinian and J. R. Lane. *For reprints, circle #4.*

New Cleaner Removes Surface Oxides From Moly Metal

A practical, low-temperature method of cleaning molybdenum has recently been developed. It is especially suitable for removing surface oxides prior to welding. The process involves two chemical baths: one at 150-180°F, the other at room temperature. *Digested from "Ryan Devises Molybdenum Cleaner," Ryan Aeronautical Company. For reprints, circle #5.*

Climax Molybdenum, Dept. 5
500 Fifth Avenue, New York 36, N. Y.
I'd like more information on:
1 2 3 4 5 6 7

Name_____

Company_____

Address_____

City_____ State_____

Steel-Weld FABRICATION

Use WELDED STEEL for Greater Strength with Less Weight!

The 46-Ton Weldment, illustrated above, is one of two Reaction Girders which, after machining, will become integral parts of a 390-Ton Vertical Lift Gate in a Lock Mechanism in the Long Sault Canal at Massena, New York. Mammoth Weldments such as this Lift Gate, and the diverse pieces at left, are typical of the thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon each year for use in processing machinery, machine tools, and other types of heavy mechanical equipment. If you are not now taking full advantage of the economies offered by welded steel components in your product, you should give the matter serious thought. In the design of almost any type of heavy machinery there are parts and sub-assemblies that can be produced more economically, more satisfactorily, and in less time, in welded steel. In weldments you get greater strength with less weight—plus the additional advantages of greater rigidity and 100% predictability. When you consider weldments, you will want to discuss your requirements with Mahon engineers; because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with complete facilities for design engineering, fabricating, machining and assembling. See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

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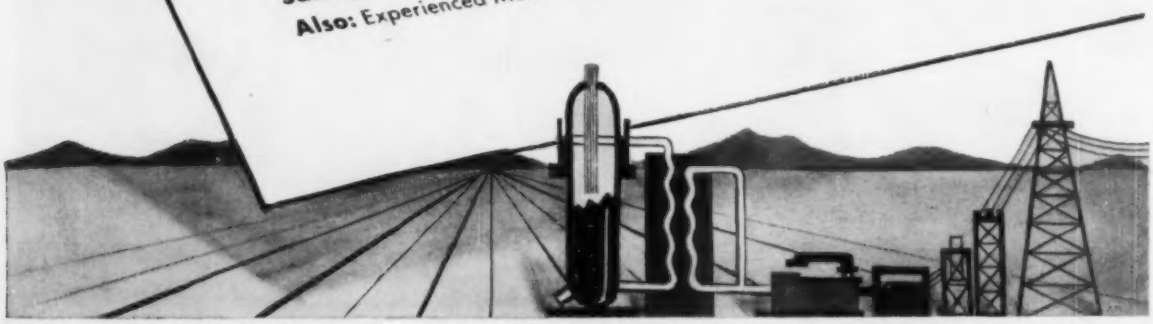


At Bettis, you'll be a part of one of the leading companies in the field of nuclear power research and development. You will have the opportunity to work with some of the most widely recognized nuclear scientists in America. As Bettis continues to set the pace in the expanding nuclear power industry, you'll advance too in position and salary, toward a successful future.

Bettis is located in South Hills, just twelve miles from Pittsburgh. This carefully chosen site provides for comfortable suburban living yet is convenient to the new metropolitan Pittsburgh with all of its educational, cultural and recreational facilities. Bettis also offers a variety of educational opportunities, including Doctoral and Fellowship programs for advanced study in the application of your specialty to the field of atomic energy.

If you feel you qualify for a career in nuclear power and you are a U. S. Citizen, write to Mr. M. J. Downey, Dept. #A-10, Bettis Atomic Power Division, Westinghouse Electric Corp., P.O. Box 1468, Pittsburgh 30, Pa.

BETTIS ATOMIC POWER DIVISION

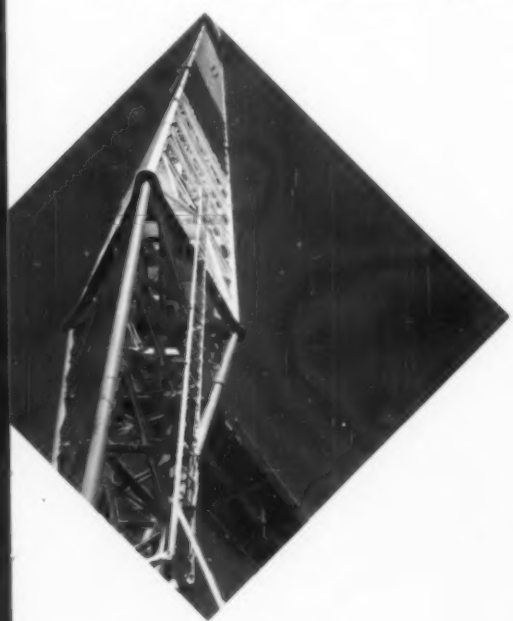
Westinghouse

BETTER YOUR FUTURE AT BETTIS

"T-1" Steel cuts cost 15% in 1,199-ft. TV Tower

THIS is the new 1,199-ft. WBZ-TV transmitting tower near Boston, Massachusetts. It's unique because up to the 838-ft. level its legs are of USS "T-1" Steel, a constructional alloy steel so strong it made possible significant savings for the tower owner. This structure was designed and built by Dresser-Ideco for Westinghouse Broadcasting Co., Inc.

WBZ's tower presently supports a 6-bay channel 4 antenna, but future plans call for it to carry plenty of additional weight; pending FCC approval, another 300 feet of height will bring it to an ultimate 1,499 feet. The tower had to be built with the strength to accommodate this extra weight without the necessity of future structural modifications.



Round, hot-rolled, heat-treated bars of USS "T-1" Steel were used for the three legs up to the 838-ft. height because this alloy steel has nearly three times the yield strength of structural carbon steel. It therefore enabled Dresser-Ideco to reduce the size of the legs greatly, lowering shipping weight, welding costs, wind stresses and over-all weight and price. For example, consider the leg members at the bottom of the tower. Cross-sectional area of these "T-1" bars is only 56% of the area required with the usual structural carbon steel, resulting in a 44% material savings. Also saved: the cost of hot-forging and machining, since carbon bars of the size required for the biggest members are too large to be produced economically by hot-rolling. *Altogether, the builders estimate that "T-1" Steel cut the cost of this tower by 15%.*

For more information on USS "T-1" constructional alloy steel, contact any office of United States Steel (listed in all phone directories), or write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. For details about the column strength of "T-1," write for free booklet.

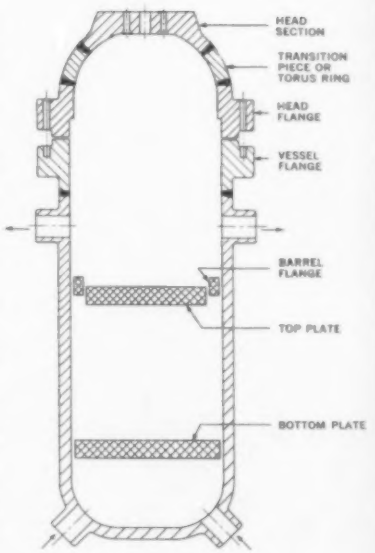
United States Steel

Critical-service reactor forgings "routine" at United States Steel

This closure-head forging for a nuclear reactor shell is a good example of how all United States Steel products are made to the tip-top edge of perfection. The reactor operates at very high pressure and is intensely radioactive. More than that, the entire shell, with its eight- to ten-inch-thick steel walls, is welded into a single, sealed unit. Can you imagine the prohibitive cost of replacing or repairing or even *examining* a forging that is in this type of service?

The small drawing shows a typical reactor vessel. "As-forged" diameters of the flange and transition forgings go up to 145 inches. They may be 30 to 50 inches thick, weighing up to 150,000 pounds in the rough. Head pieces, like the one in the big color picture, go up to 96 inches in diameter, 36 inches thick, 87,000 pounds.

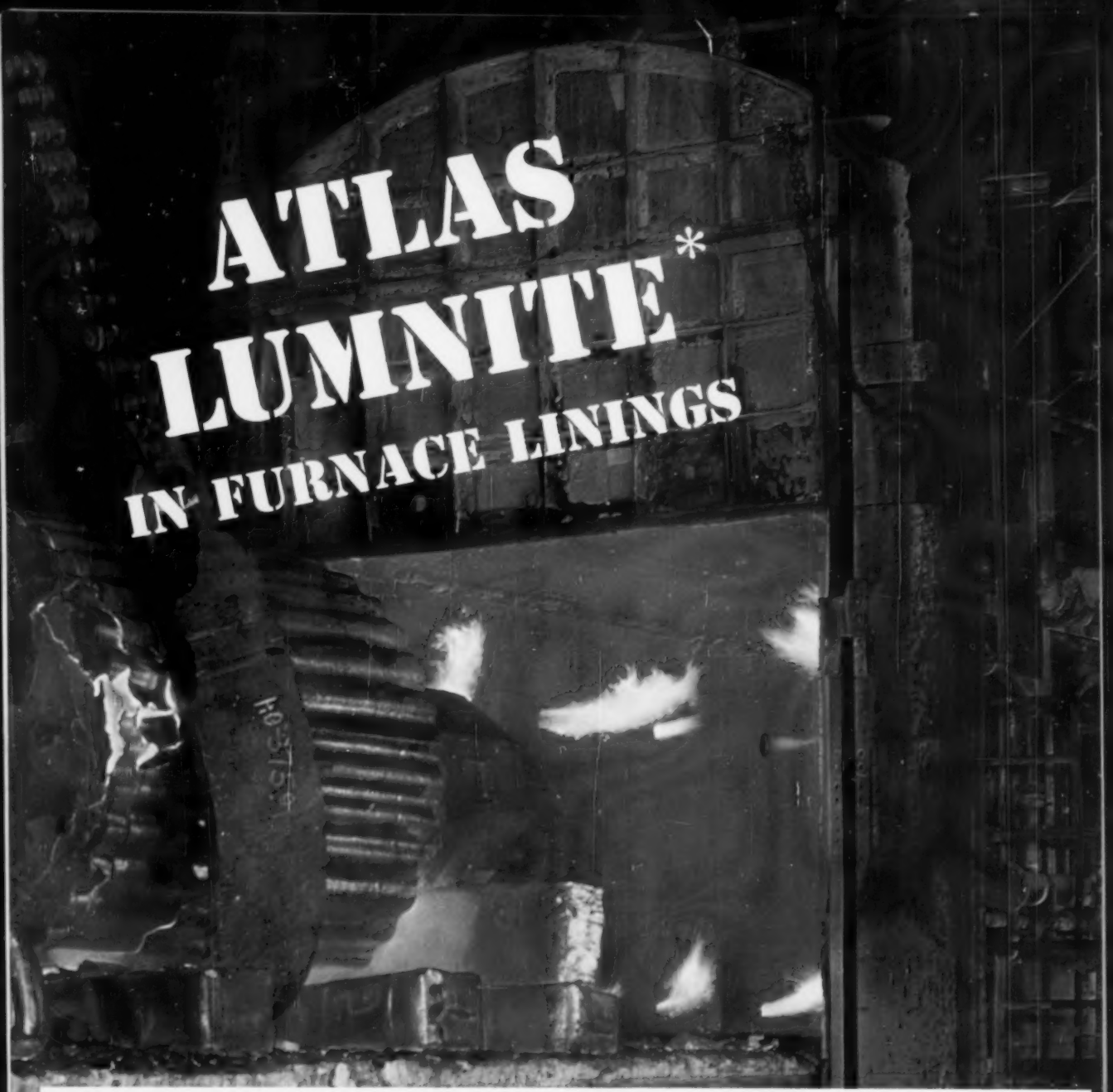
To make these mammoth forgings, we teem manganese-nickel-molybdenum killed steel ingots that may weigh a quarter-million pounds. The ingots are cogged, upset, punched and mandrel-forged (in the case of ring forgings) and are annealed, double normalized, and double tempered—a process that may take as long as 700 hours. Then comes the rough machining on vertical boring mills, and quench and temper heat treatment. Inspection procedures are elaborate: ultrasonic inspection, magnetic particle inspection, plus tangential tensile, Charpy V notch impact, grain size and bend tests.



It's no surprise that so many builders of nuclear equipment specify and depend on USS Quality Forgings. The men of our Homestead Forgings Division who produce these parts have had a great deal of experience turning out equally critical forgings, such as the perfectly balanced shafts for steam turbines and generators. Critical work like this is routine, and perfection is a habit for the men who make USS Quality Forgings.

You get this same quality in *any* forging you order, because the same crew of highly skilled men work on every order, using the same steelmaking facilities and the same shop equipment. If you specify a USS Quality Forging, you can be sure that money won't buy anything better. We'd appreciate your inquiries or requests for our free 32-page booklet on USS Quality Forgings. Write to United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

USS United States Steel



Refractory concrete linings, containing LUMNITE cement, give excellent service in car-bottom forge furnaces, Homestead Works, United States Steel Corporation, Munhall, Pa. Packaged castable used: Laclede-Christy "Steel Cast," product of Refractories Division, H. K. Porter Co., Inc. Operating temperature: 2200°F.

- Refractory concrete furnace linings made with LUMNITE cement resist extreme variations in temperature and thermal shock due to rapid heating and cooling.
- Construction is fast and easy . . . simply pour refractory concrete into forms . . . service strength is reached within 24 hours.

For maximum convenience, use castables made with LUMNITE cement. These are packaged mixtures, ready for use. Just add water, mix and place. Made and distributed by leading manufacturers of refractories.

For more information, write: Universal Atlas, 100 Park Avenue, New York 17, N. Y.

*"LUMNITE" *is the registered trademark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company*

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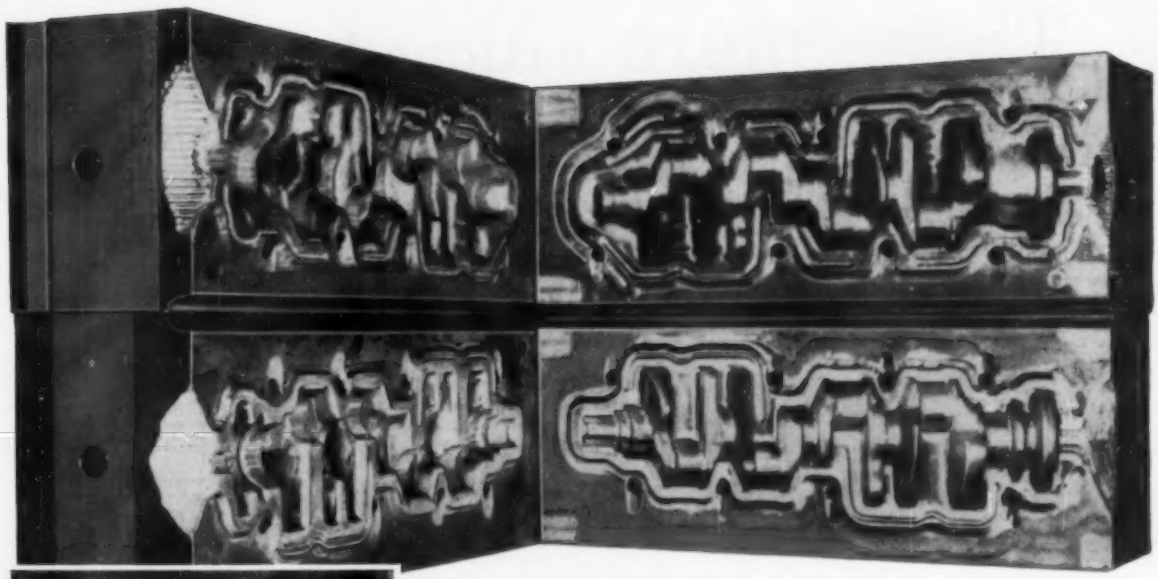

USE FINKL DIE BLOCKS FOR QUALITY FORGINGS

...the automotive industry does!

An upstate New York forge shop specializes in the forging of crankshafts, knuckles, and other high production items used in automotive production. Because the volume of each particular forging is very high, it is possible to evaluate costs and study tooling very closely

In the illustration above, the manufacturer is using Durodi for both the blocking and finishing crankshaft impressions in this forging press operation.

Durodi, made by Finkl electric furnace quality steel practice is a high volume producer and a most practical hot work tool for close die forgings. It hardens deeply and uniformly, is resistant to abrasion and withstands both shock and impact loading at high hardness. Its Special Machining Quality also appreciably reduces sinking time. All of these advantages mean more production at less cost.

Finkl die blocks are available in several grades, all sizes and tempers to handle virtually any forging requirement. Call your local Finkl representative next time you are considering die blocks or forgings. He will be glad to help you and there is no obligation.

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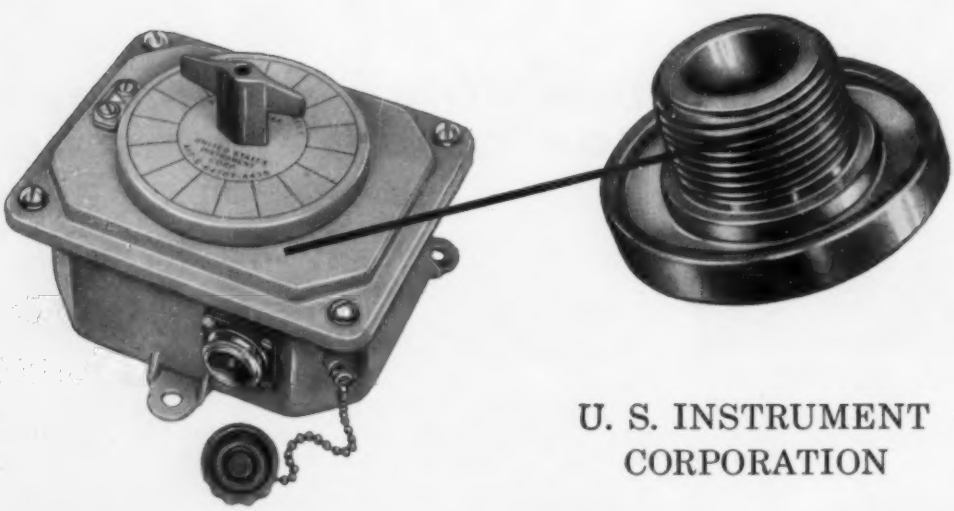
Three more nationally known manufacturers select Mueller Brass Co. Forgeable Bearing Alloys for vital components of their products

In ever-increasing numbers, Mueller Brass Co. specialized alloys are being specified by manufacturers of top-quality products. In a series of continuing advertisements, we have presented case histories of successful applications, to which we now add three more distinguished companies who are incorporating Mueller Brass Co. forgeable bearing alloys in their products to meet the demands of widely divergent operating conditions.



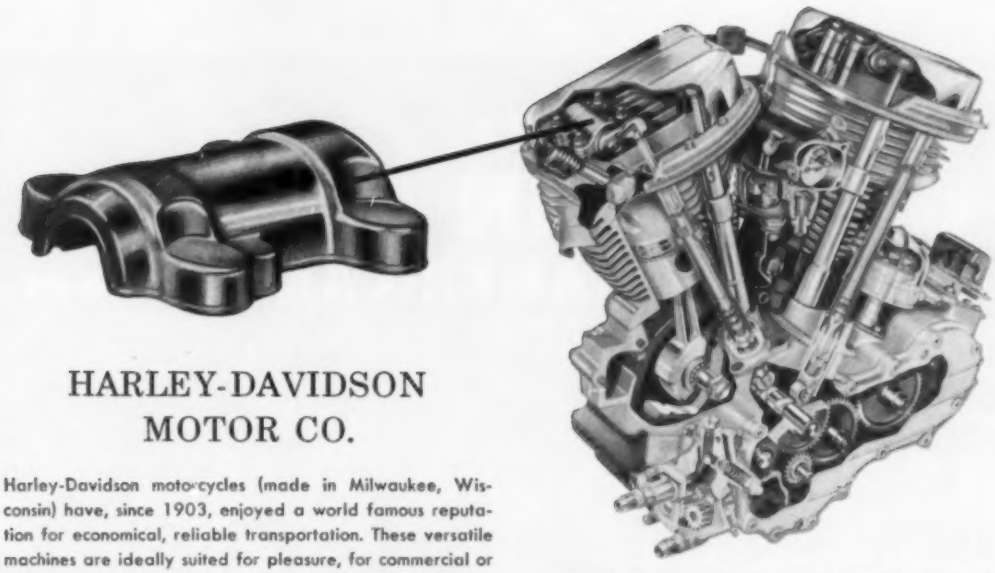
U. S. INSTRUMENT CORPORATION

U. S. Instrument Corporation, Charlottesville, Va., selected abrasive-resistant Mueller bronze alloy bushings for their remarkable telephone selector switches after exhaustive tests of many materials. A vital communications link on today's U. S. Naval vessels, these sound-powered telephone circuits must meet rigid Navy performance-standards. Such phones, for example, must have selector switches which are capable of rotating for a minimum of 50,000 torturous cycles . . . 360° clockwise, followed by 360° counter-clockwise. In addition, the "O" ring must still form a water-tight seal AT THE END OF THE TEST! Of the many tested, a Mueller Brass Co. special manganese bronze alloy was the best one meeting these rigid specifications.

There were other important reasons why these bushings were chosen by U. S. Instrument Corporation for this application. Resistance to abrasive action against the rubber "O" ring was a prime one . . . then, too, the stem assembly suffered severe pounding through the action of the indexing mechanism which, prior to the use of the Mueller Brass Co. alloy, caused repeated seizure of the component parts. In this particular application, the part was fabricated on an automatic screw machine rather than produced as a forging. The versatility of Mueller Brass Co. alloys makes them readily adaptable to the most economical method of fabrication dependent upon the size, shape, and end-use requirements of the part.

In commenting on the success of this part, U. S. Instrument Corporation praised the alloy for its tensile strength (ordinary brasses could not withstand the 2000 ft. lb. impacts without deformation), for its machinability and corrosion-resistance.

MUELLER BRASS CO.



HARLEY-DAVIDSON MOTOR CO.

Harley-Davidson moto-cycles (made in Milwaukee, Wisconsin) have, since 1903, enjoyed a world famous reputation for economical, reliable transportation. These versatile machines are ideally suited for pleasure, for commercial or business use, as well as the grueling demands of law enforcement work. Harley-Davidsons boast a dependable engine . . . one which can roll up an astounding mileage record with little or no care. The painstaking selection of every engine component is one important reason for this reliability. The new twin-cylinder Harley-Davidson 74 OHV employs Mueller Brass Co. bronze alloy forgings in the form of rocker-arm bearing caps. Subjected to violent temperature changes, fast starts and stops and road shock, Mueller forgings are proving again and again that they have the ability necessary to withstand almost any punishment . . . and still provide unfailing service.

JACOBSEN MFG. CO.

Jacobsen Mfg. Co., Racine, Wisconsin, was among the first to produce a practical power mower for home use. That was more than 35 years ago! Today, Jacobsen power-mower dependability is evident itself in more than a dozen gleaming new models such as the popular Pacer, Lawn Queen, Manor and others. One of the most reliable components in the always dependable Jacobsen hi-torque engine is a Mueller Brass Co. connecting rod forged from special bronze alloy. Jacobsen mowers with Mueller-forged connecting rods are called upon by some commercial users to operate as much as 8 hours daily, 6 days a week . . . perhaps as much as 2000 hours a year. In searing summer temperatures, thru hours of constant operation, the high uniform strength of Mueller bronze forgings constantly withstands pounding and vibration with the same conspicuous success as in its many other applications.

Why not investigate these specialized alloys for your own products. We welcome your inquiries. Our engineering staff will be happy to make specific recommendations. Both on the proper alloy and the best method of fabrication to meet your needs . . . exactly. Our engineering manuals show many, many examples of how American manufacturers have used these alloys to great advantage.

● WRITE TODAY FOR THE ENGINEERING MANUAL YOU NEED

- **Mueller Brass Co. Forgings** Engineering Manual H-58565 ☐
- **Tuf Stuf Aluminum Bronze Alloys** Engineering Manual H-58563 ☐
- **"600" Series Bearing Alloys** Engineering Manual FM-3000 ☐
- **Copper Base Alloys in Rod Form** Engineering Manual FM-3010 ☐

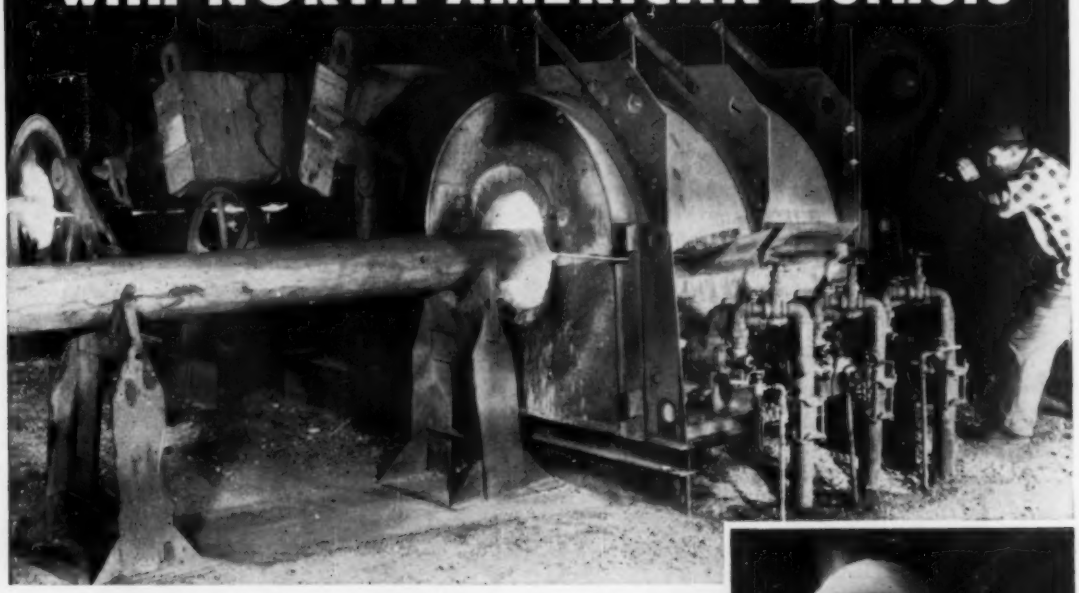
227

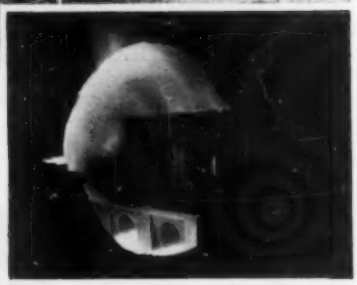
P O R T H U R O N 2 8 , M I C H I G A N

Huge Crankshafts

GET HOT IN A HURRY

with NORTH AMERICAN Burners





High speed heating, such as usually applied to small parts in mass production, is used by **Erie Forge & Steel Corporation** for heating huge locomotive crankshafts for die press forging . . . convincing evidence of the efficiency of North American Burners and Blowers.

Amazingly, **#6 oil** is used to fire these compact barrel-type furnaces. North American Blowers and Series 212 Burners provide thorough atomization for fast heat release.

8⅞" billets are heated from 1100 F to 2350 F in a day-long **average** time of 36.9 minutes. The result—superior quality metal. Average oil consumption is 32 gallons per ton of steel. It will pay you to look into the results you can expect by installing North American for high speed heat release.

Large photo shows 8⅞" billets in 2 of 8 small (36" I.D.) furnaces. Note Burners in right foreground.

Small photo is a close-up view showing burner tiles and flames whipping around a partially forged 10" crankshaft in a large furnace.

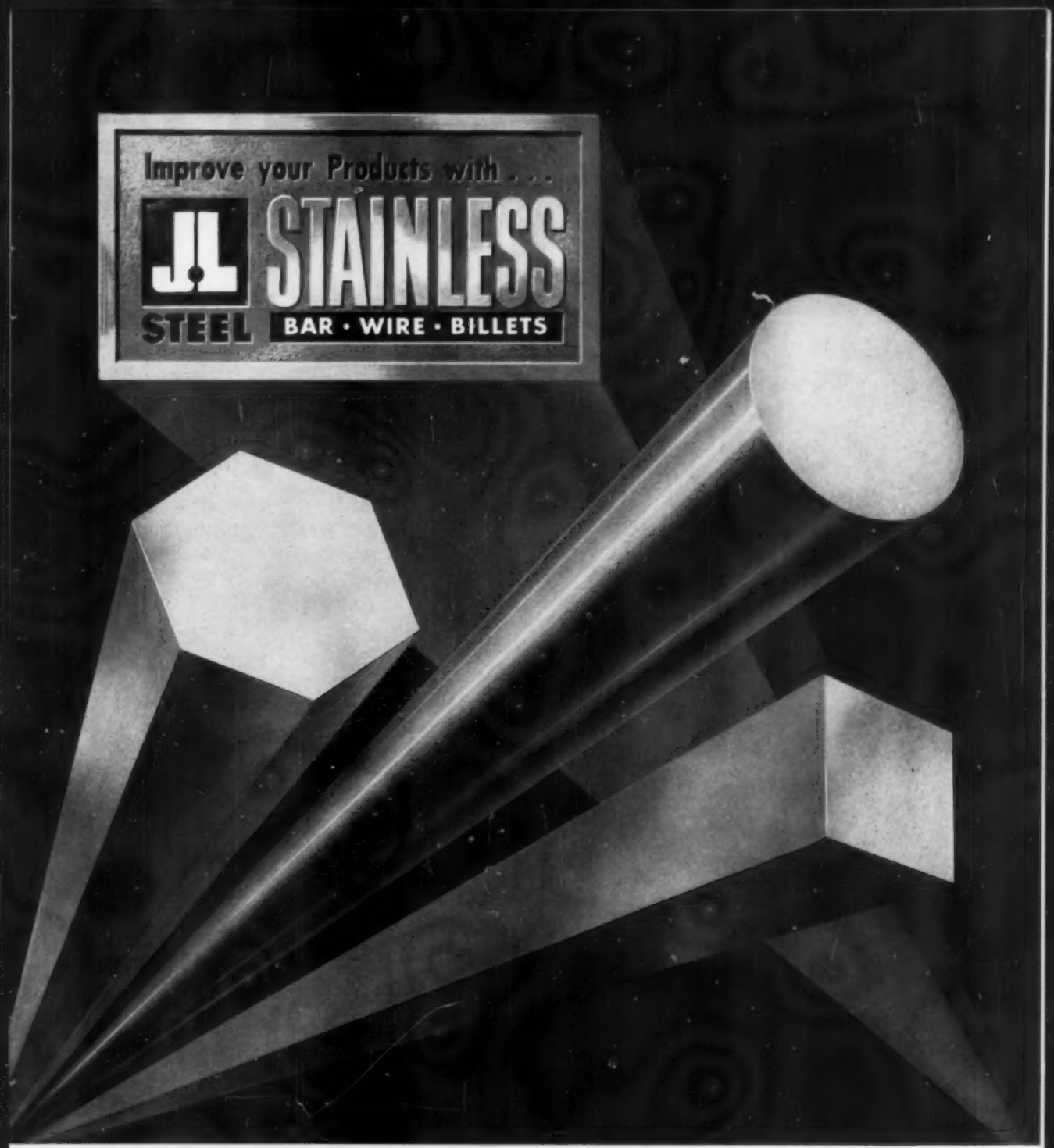
For detailed engineering information, consult your nearby North American combustion specialist. For equipment information, write for bulletin.

NORTH AMERICAN COMBUSTION Since 1917

The **NORTH AMERICAN** Manufacturing Co.

Combustion Engineers

Cleveland 5, Ohio



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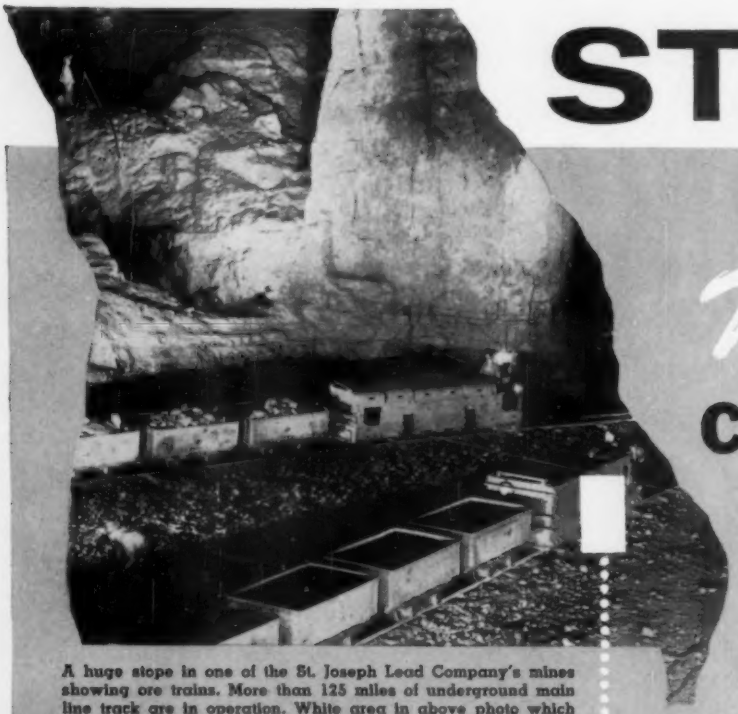
ST. JOE

The ONLY *Natural* CHEMICAL LEAD

combines a lower creep rate with greater corrosion resistance than lead produced from any other ores to which copper has been added



A huge stope in one of the St. Joseph Lead Company's mines showing ore trains. More than 125 miles of underground main line track are in operation. White area in above photo which has been silhouetted in the shape of the state of Missouri, indicates lead belt location.

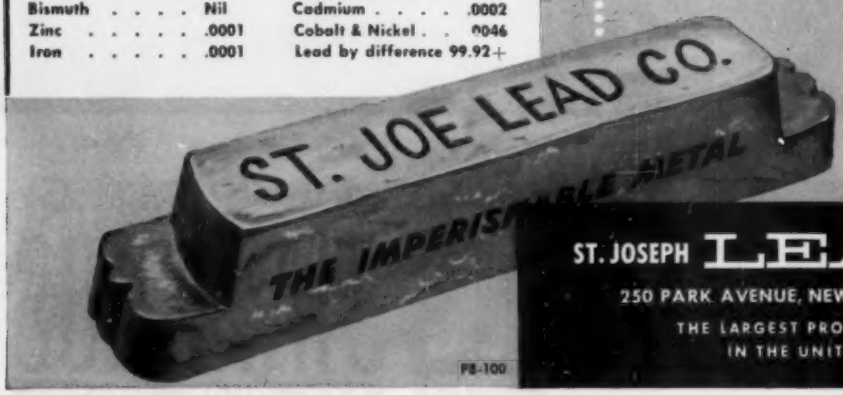
According to the American Society of Testing Materials "Chemical Lead has been used for many years in the trade to describe the undesilverized lead produced from South East Missouri ores".

The huge ore bodies of South East Missouri from which St. Joe Chemical Lead has been produced continuously by this company since 1865 early became known as chemical lead owing to the unusual properties which it possesses. As can be seen from the analysis, it contains certain percentages of copper, silver and nickel. These elements—*which have not varied, quantitatively, for over ninety years*—combine to render the metal particularly immune to corrosive attack, give it an extremely low creep rate under steady stress and a high resistance to fatigue failure.

This combination of advantageous properties — unique in St. Joe "natural" copper-bearing lead—is also responsible for the fact that more pipe and sheet have been manufactured from St. Joe Chemical than from any other brand of lead.

TYPICAL ANALYSIS OF ST. JOE CHEMICAL LEAD

Silver	.0100%	Arsenic-Antimony-Tin Combined	.0002%
Copper	.06	Cadmium	.0002
Bismuth	Nil	Cobalt & Nickel	0046
Zinc	.0001	Lead by difference	99.92+
Iron	.0001		



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the Natural
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THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

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Olin Mathieson Chemical Corporation,
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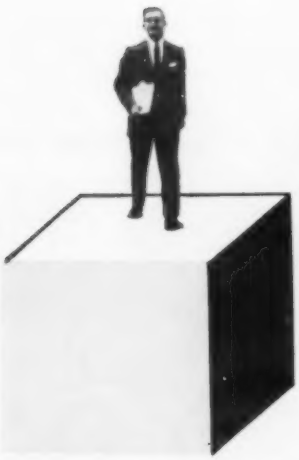

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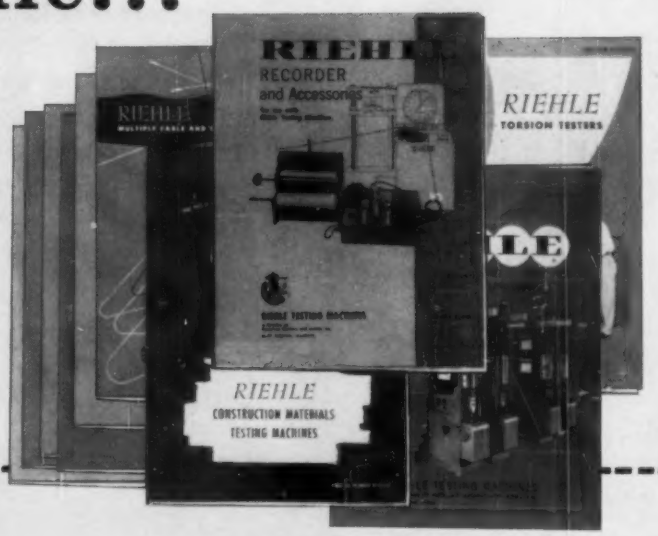

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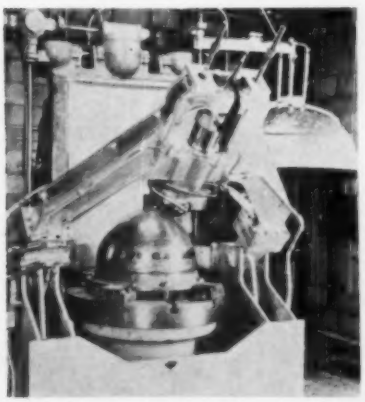
APPLICATION and EQUIPMENT new products

Titanium Spinning

A process for hot-spinning thick titanium alloy hemispheres has been announced by Titanium Fabricators, Inc. 6Al 4V heat-treatable titanium alloy is used. Circular blanks are

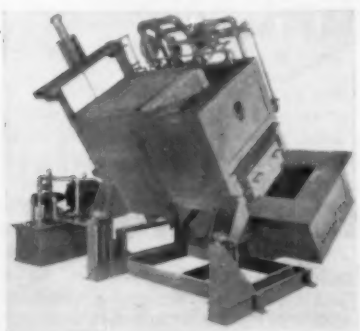


pre-heated and then hot spun. The vertical spinning machine is completely hydraulic, and permits controllable feeds, speeds and pressures. Finished spherical vessels are being produced with 16, 22, and 25 in. diameters.

For further information circle No. 241 on literature request card, page 48-B.

Tilting Furnaces

A new line of nose pouring furnaces, available with hydraulic tilting mechanism, has been announced by the Combustion Div., Eclipse Fuel Engineering Co. Furnaces are of the double-chamber, dry-hearth design

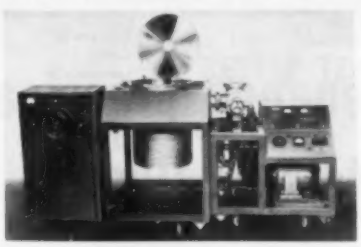


and are rated at 600, 750, 1000, and 2000 lb. per hour. Holding bath temperature is sensed by a thermocouple in the dipout vestibule. Molten metal from the dry hearth enters holding bath in a continuous trickle at the same temperature as the bath itself. Closed-flame burners are supplied for gas, oil, or combination gas/oil firing. Both melting and holding chamber have their own burner system.

For further information circle No. 242 on literature request card, page 48-B.

Laboratory Furnace

A new laboratory vacuum furnace, built on the modular principle has been announced by the Vacuum Equipment Div. of the New York Air Brake Co. The furnace assembly may be used for melting, casting, annealing, alloying, sintering, heat treating and crystal growing. The standard F-15 furnace consists of a water-cooled furnace chamber 18 in. in diameter by 24 in. deep; a portable



pumping system consisting of a fractionating diffusion pump, a mechanical vacuum pump and a cold trap; a resistance or induction heating power supply; and heating element assemblies required for the different operations involved. Capable of temperatures in excess of 3600°F. and with a crucible capacity of 5 lb. of steel (or equivalent in other metals), it can reach a pressure of 1×10^{-4} mm. Hg in 20 min., and an ultimate pressure of 1×10^{-5} mm. Hg.

For further information circle No. 243 on literature request card, page 48-B.

X-Ray Viewing

An electronic instrument that increases the readability of X-ray negatives through contrast enhancement has been announced by the Government and Industrial Div. of Philco Corp. The system consists of a monochrome television monitor, operator's console and a flying spot scanner. An

X-ray negative placed before the flying spot scanner is magnified and reproduced in enhanced monochrome. Negatives may be shifted about to obtain magnified images of any portion.

For further information circle No. 244 on literature request card, page 48-B.

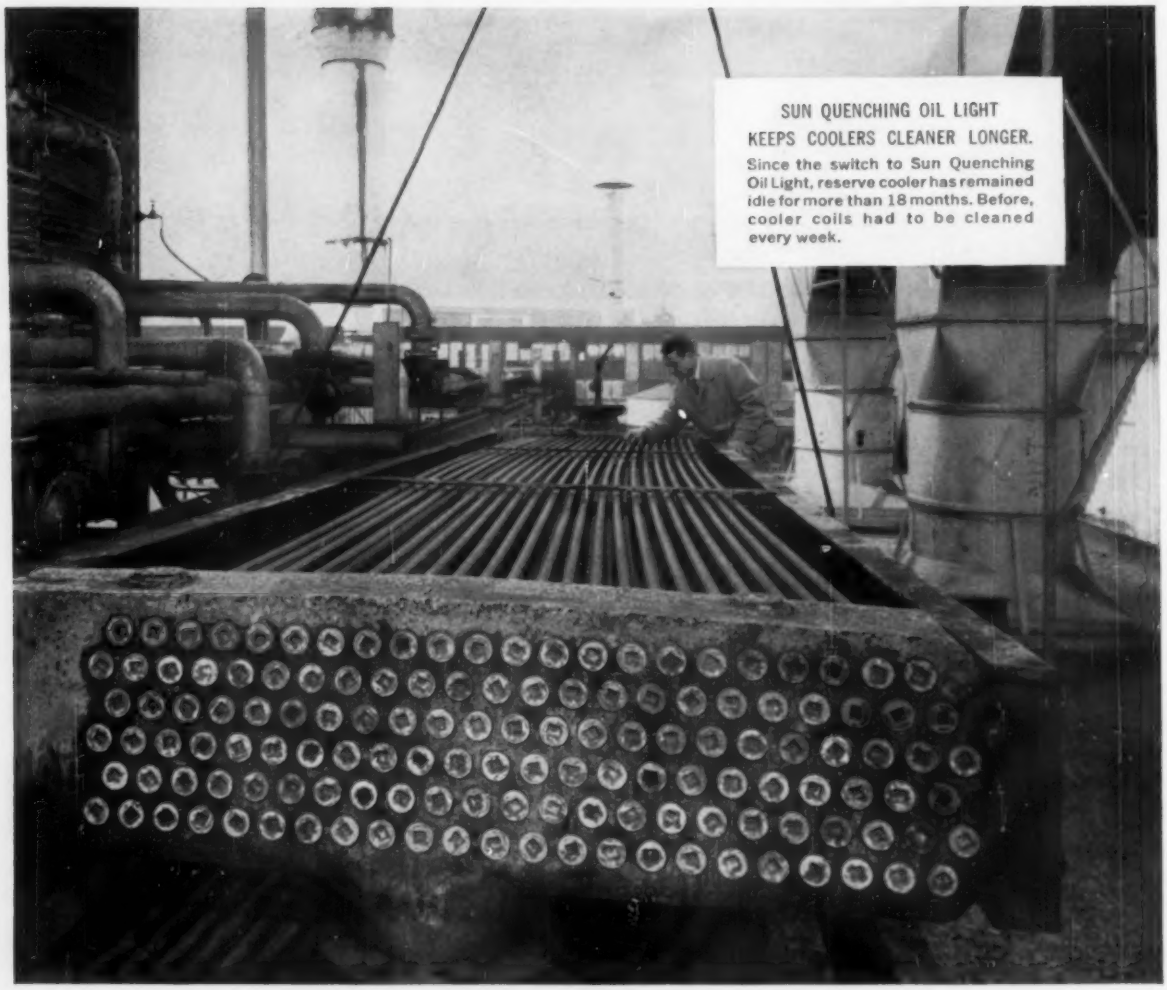
Resistance Alloys

A new iron-chromium-aluminum alloy for use in moderately high-temperature electrical resistance heating applications has been announced by Hoskins Mfg. Co. Alloy 835 may be used where continuous operating temperatures do not exceed 2250°F. The alloy was developed for use as a heating element in electric furnaces and kilns, radiant quartz tubes for paint drying ovens and oil burner igniter coils. It has an electrical resistivity of 835 ohms per circular mil foot at 68°F. While Alloy 835 is quite resistant to sulphur corrosion, it is not recommended for use in reducing atmospheres other than dry hydrogen.

For further information circle No. 245 on literature request card, page 48-B.

Vacuum Furnace

A new vacuum induction melting and casting furnace of four-chamber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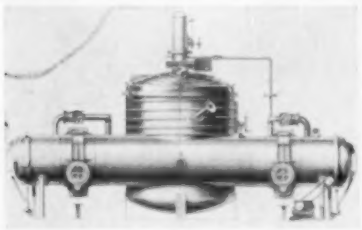
design has been announced by the Kinney Mfg. Div. Capacities range from 300 to 5000 lb. of steel. The furnace has a vacuum lock system that does not require breaking vacuum in the main furnace chamber for the introduction or removal of molds. The four basic sections of the unit, operating as separate vacuum chambers, consist of: (1) the



main vertical furnace chamber containing the induction heating coil and crucible assembly for tilt-pour operation; (2) the removable charging chamber that fits over a gate valve permanently attached to the cover of the main furnace; (3) a mold entrance lock at one end of the mold tunnel equipped with special hinged door to isolate from atmosphere; (4) a mold exit lock in the other end of the mold tunnel.

For further information circle No. 246 on literature request card, page 48-B.

Compression Tester

Steel City Testing Machines has announced a new hand operated tester for low capacity compression testing. Model CT-134 is operated

by turning a knurled knob at the bottom of the tester. The lower platen is raised, applying the load. Guides along the side keep the platen from turning. The load measuring system incorporates a bourdon-type gage, a cylinder and piston, and a trapped oil reservoir. Model shown has a capacity load of 300 lb., occupies a bench space of 11 by 6 in., has overall height of 26 in. and net weight of approximately 40 lb. Vertical opening is adjustable from 4 to 5½ in.

For further information circle No. 247 on literature request card, page 48-B.

Plating Baths

Allied Research Products has announced a zinc purifier for preventing the accumulation of harmful impurities in zinc plating baths. ARP #12 is a concentrated liquid which is diluted with water and added to the plating bath. It precipitates heavy metallic impurities (including lead and cadmium) which can cause dullness and blistering in zinc plate and removes carbonates at about the same rate as that at which they are formed.

For further information circle No. 248 on literature request card, page 48-B.

Environmental Testing

A new environmental test machine has been announced by Cincinnati Sub-Zero Products. This unit was recently put in use by Federal Telecommunications Laboratories for testing transistors. It is adjustable from −50 to +200°F. and will maintain a relative humidity of 95% ±5% between −80 and +160°F. This model has a clear working area 24 by 24 by 19 in. Air circulation and heat

are provided by a fan coil and blower assembly on the back wall. The single-stage refrigeration system is equipped with a 1 hp. hermetic motor compressor which operates on 230 volts, 60 cycle, single phase power.

For further information circle No. 249 on literature request card, page 48-B.

Pressure Gage

A new recording pressure gage which uses a 3-in. strip chart has been announced by the Bristol Co. The gages are offered in ranges from 0 to 3 psi. up to 0 to 60 psi. Elements in various ranges are Ni-Span C,

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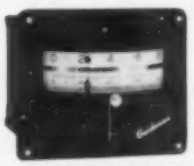

WHAT DOES
BETTER TEMPERATURE CONTROL
MEAN TO YOU?

It might mean greater accuracy . . . more consistent reliability . . . simplicity . . . elimination of vacuum tubes or possibly compactness or low cost. Another way, it could mean greater volume of production . . . improved quality . . . lower unit-costs. *Any* way, in many different fields, it means instruments by WEST.

Here and abroad we produce a wide selection of controllers, indicators and recorders for temperature and other variables, as well as complete systems and accessories. Our men in scores of cities offer qualified counsel. Write for Bulletin COM.

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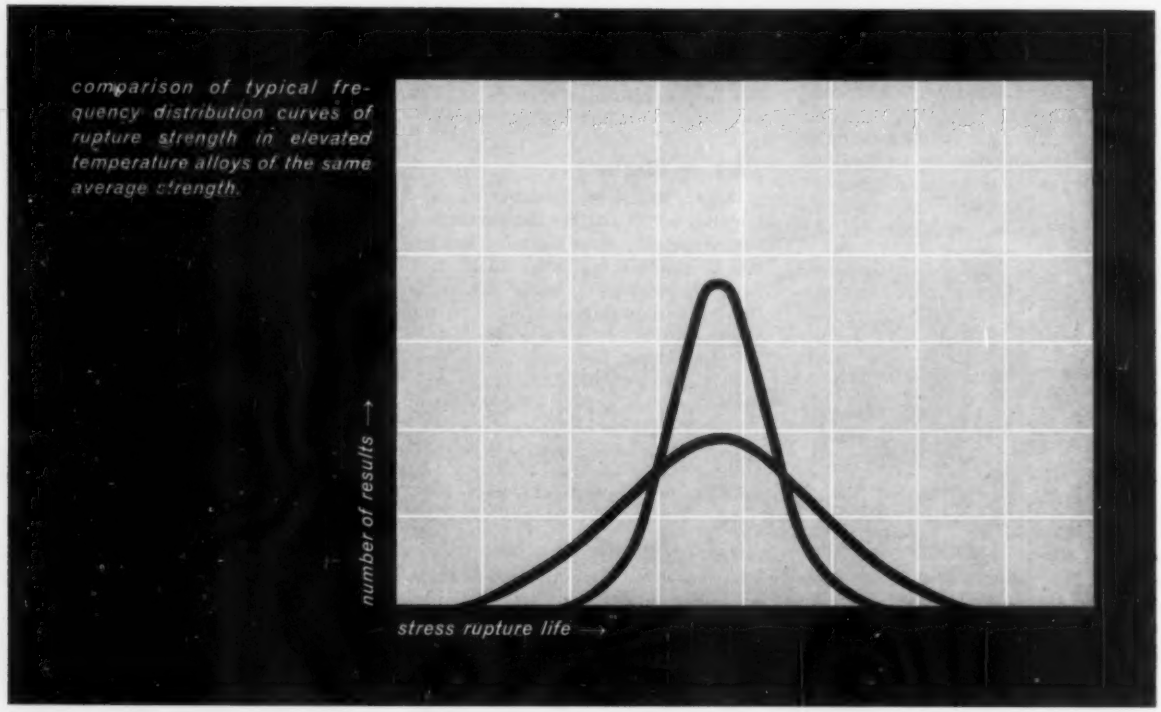

comparison of typical frequency distribution curves of rupture strength in elevated temperature alloys of the same average strength.
number of results →
stress rupture life →

why consistency is important to every designer who uses elevated temperature alloys

The broader curve is characteristic of elevated temperature alloys generally used today. Its shape shows parts made from this alloy will have widely varying service lives.

The steep curve is typical of Carpenter alloys for elevated temperature service. It shows one reason why Carpenter alloys are becoming so widely used — they're so consistent in performance.

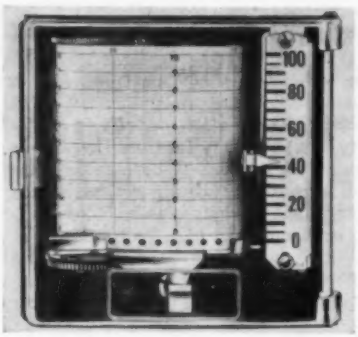
Fabrication properties are just as outstanding. Forge shops, fastener makers, engine builders report better finishes and fewer rejects with Carpenter high temperature alloys than with similar types produced by others. Carpenter alloys have gained an enviable reputation for exceptional cleanness, forgeability and machinability wherever they are used.

Predictable performance and outstanding fabrication properties of Carpenter elevated temperature alloys are made possible by the most exacting standards of quality control, typical of Carpenter's leadership in the technology of specialty steels.

Write today for your copy of the new booklet, "Carpenter Alloys for Elevated Temperature Service". Or ask the Carpenter representative who calls on your company. The Carpenter Steel Company, 133 W. Bern Street, Reading, Pa.

Carpenter STEEL

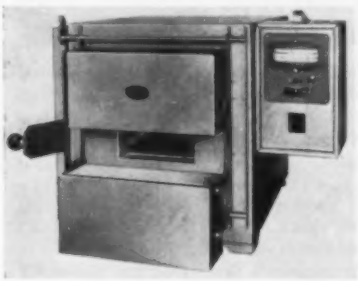
Improved alloys for elevated temperature service



beryllium copper, and phosphor bronze. All models are available with either pneumatic or electric chart drives, in a variety of chart speeds.
For further information circle No. 250 on literature request card, page 48-B.

Furnaces

Thermo Electric Mfg. Co. has announced the addition of four completely new electric bench-type furnaces. Designated as Type 1800 furnaces, they all have the same chamber dimensions, case size and general construction but differ in power requirements (single or 3-phase) and top temperature limits (2000 or 2300°F.). Each furnace has 7½ in. of fire-brick and back-up



insulation surrounding the heating chamber. Power is consumed only 35% of the time, leaving a reserve for heavy load requirements, fast heating and quick recovery time. Type 1800 furnaces are fitted with double doors. If limited access to the chamber is desired, the lower section alone can be opened or if full access is required, both sections can be opened. Twelve elements are held in refractory supports which line the top, bottom and sides of the chamber. They are made of large-diameter wire.
For further information circle No. 251 on literature request card, page 48-B.

Ferro-Tungsten

A new product, called M and R tungsten sponge mix, for use as a tungsten additive has been announced by Metals and Residues, Inc. When the mix is heated to a sufficiently high temperature, it yields a porous, sponge-like mass of metallic tungsten.
For further information circle No. 252 on literature request card, page 48-B.

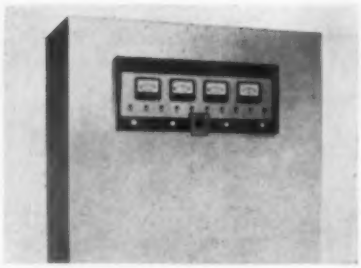
Heat Exchangers

Expansion of its line of impervious graphite shell and tube heat exchangers has been announced by National Carbon Co. Three new sizes, with 8, 42, and 45-in. diameter shells, are available for corrosive service. Different sizes contain from 9 to 685 impervious graphite tubes ⅞-in. i.d.

Standard tube lengths are 6, 9, 12, 14, and 16 ft. The picture above shows two 45-in. heat exchangers nearing completion.
For further information circle No. 253 on literature request card, page 48-B.

Induction Heating

Induction Heating Corp. has announced a new induction heating



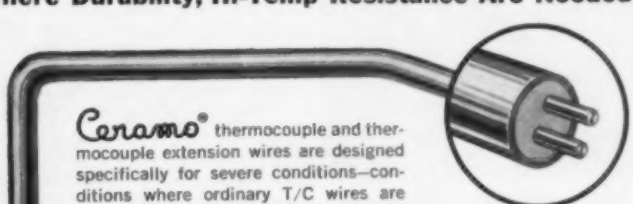
frequency transformer capable of converting 3-phase, 60-cycle power to single-phase, 180-cycle output. It has no moving or rotating parts, spark gaps or electronic tubes. Frequency multiplication is accomplished by means of static conventional capacitors and transformer-like devices. The main components are water-cooled. The standard input is 440 volts, 3-phase, 60 cycle. Other operating voltages are available. Units range in size from 50 to 300 kw. output.
For further information circle No. 254 on literature request card, page 48-B.

Creep Testing

The Tinius Olsen Testing Machine Co. has announced a new air-operated stress rupture and creep testing machine. Infinitely variable loads to 30,000 lb. may be applied and main-

Ceramo® Thermocouple Wire Meets Severe Conditions

Where Durability, Hi-Temp Resistance Are Needed



Ceramo® thermocouple and thermocouple extension wires are designed specifically for severe conditions—conditions where ordinary T/C wires are inadequate. First developed by Thermo Electric, "Ceramo" wires incorporate ceramic insulation with overall metal sheathing. They'll solve your problems of high temperature, abrasion, chemical or corrosive action, pressure and difficult installation. You can bend them to almost any shape. As extensions, you can often use them without conduit. And under these conditions they'll outlast comparable standard types many times—with no significant difference in response. Choice of conductors in all standard calibrations and various sheath materials for temperatures up to 3000°F. Conductors—36 to 12 gage. Overall diameters—1/25″ to 7/16″ for thermocouples; ⅛″ and ¼″ for extensions.

Write for Bulletin No. 31-300-H.

Thermo Electric Co. Inc.
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

ACHESON

dispersions digest

Reporting uses for

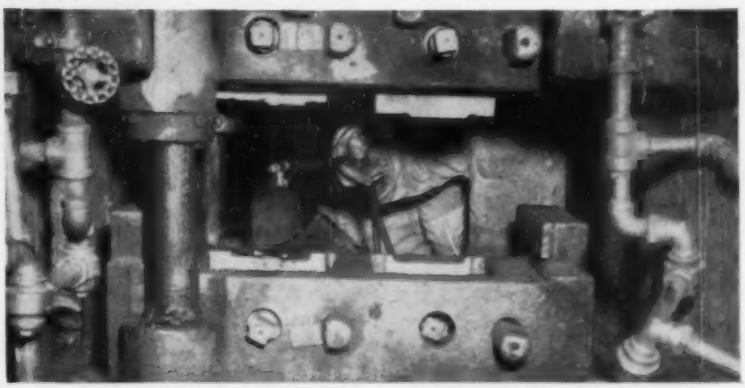
dag® BRAND DISPERSIONS

COLLOIDAL GRAPHITE, MOLYBDENUM DISULFIDE, VERMICULITE, AND OTHER SOLIDS

COLLOIDAL GRAPHITE PROVES IDEAL AS FORGING LUBRICANT

Lubricants to be suitable for use on forging dies for steel and nonferrous metals must be stable under the high temperatures and pressures involved. Besides providing the most effective lubrication for hot-work dies, 'dag' brand dispersions act as coolants. Total advantages gained by using Acheson colloidal graphite, as described in the following applications are: improved quality of the forging, reduced die wear, lower production costs, and improved working conditions.

'dag' dispersion improves quality, cuts costs for Utica Drop Forge and Tool Division. With a large share of their capacity being devoted to the forging of jet engine blades, Utica finds it must maintain high production, consistently high quality, and a competitive price. Blade-forging dies have a comparatively short life due to rapid wear caused by the thinness of the blades, the high pressures required to form the heat-resistant alloys used, and the closer tolerances required. They have found that *every one* of these requirements can be met by using 'dag' colloidal graphite dispersed in water as their forging lubricant. First, it must withstand temperatures which range from 1950-2200° F. Sprayed on both halves of the die it forms a tightly adhering, smooth, microscopically-thin film that aids metal flow and substantially protects the die itself. In many cases, this has meant fewer finishing operations and therefore higher production, due to the improved quality of the blades. A compressor blade formerly required four blows from upset to finish, with an intermediate heat and tumbling operation. Now, this operation is done in only two blows from original heat. The savings . . . $16,000 a year on this part alone! Add increased life of these precision dies and you can appreciate what a 'dag' colloidal graphite dispersion means to efficient forging. Utica finds water-based dispersions best for press forging, and colloidal graphite in oil the best lubricant for hammers.



Operator spraying colloidal graphite on both top and bottom die halves before forging jet engine blades at Utica Drop Forge and Tool Division. Kelsey-Hayes Company.

Write for additional information contained in Acheson Bulletin No. 426. Address Dept. MP-28.

Concentrated Acheson colloidal graphite being applied to die surfaces before they are put in service.

Pre-treatment and operational use of 'Aquadag' greatly increases die life. Before putting dies into service, a prominent midwestern manufacturer finds that by preheating them to about 250° F. and brushing on a dispersion of colloidal graphite in water, they have generally *doubled* the working life of their dies. When used as an operational lubricant, actual measurements of wear on a die for a truck body brace were only *one-third* the former rate. And this was with 'Aquadag' diluted 1 to 240 in water! . . . Ample proof of the wide coverage, film toughness, lubricity, and basic economy of a 'dag' brand dispersion.

Colloidal graphite is resistant to heat, does not react with the die steel, and the extremely small particle size permits an actual adsorption to the metal surface. A water carrier eliminates the usual smoke and fumes thus affording better working conditions and keeping die temperatures down. After the carrier evaporates, a dry graphite film remains which, besides being an efficient lubricant, protects the die from the accumulation of abrasive dust and scale. Die life is extended from 8 to 14 days and production increased by the reduction in downtime.

Specially compounded, ready-to-use forging lubricants containing 'dag' colloidal graphite are available from industrial lubricant suppliers. If you have a forging lubrication problem, it may pay you to call in your Acheson Service Engineer.

ACHESON *Colloids Company*

PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.

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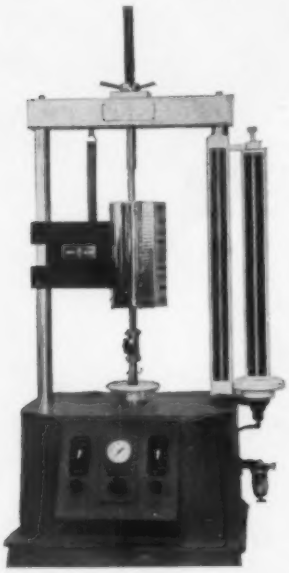
tained regardless of normal fluctuations in line pressure. Load is indicated by either of two mercury column indicators: low range of 0 to 6000 lb. and high range of 0 to

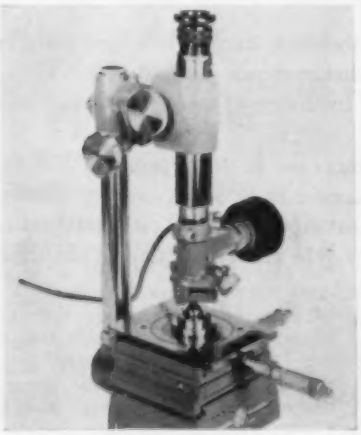


30,000 lb. Specimen may be tested at any temperature from 0 to 1800 or 2000°F., which is automatically maintained by an electrically operated furnace. The unit is available with a variety of extensometers.

For further information circle No. 255 on literature request card, page 48-B.

Surface Roughness

Engis Equipment Co. has announced a Hilger & Watts surface finish microscope which permits checking surface finish in terms of wave length of light by using interference fringes. Roughness of flat or curved surfaces can be measured directly to an accuracy of 0.000001 in. without calculations or use of tables. The image of the surface



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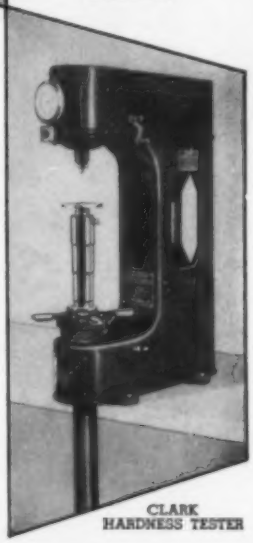
THE MOST FOR YOUR "ROCKWELL TESTING" DOLLAR!

The Clark Hardness Tester is precision built to give guaranteed precision results. Thousands of Clarks, with years of service all over the world, attest to this.

The surprisingly low price includes the precision Clark Diamond Cone Penetrator, as well as Steel Ball Penetrators, a wide assortment of Anvils, Test Blocks, and other accessories. Available in two models, for Standard and Superficial "Rockwell" hardness testing, each with **choice of 4", 8", 12", or 16" work capacity.**

Before you invest in any hardness tester, get the facts about the low price, speedy delivery, and *guaranteed accuracy* of the Clark. Write today.



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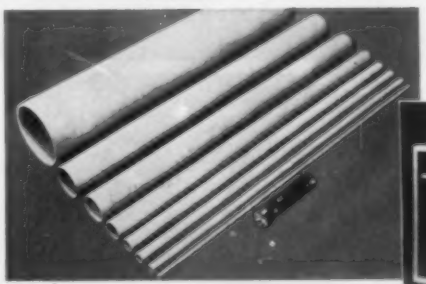
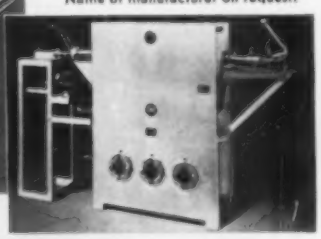


Furnace below equipped with McDanel Zirco Tube, 46" long, 1½" I.D., 1¾" O.D. Operates at temperatures from 1,650 to 3,000° F. Name of manufacturer on request.



Protection Tubes Help Produce Controlled Atmosphere at 3,000° F. In Research Electric Furnace

Sintering, brazing and other heat-treating experiments are conducted in this laboratory furnace applied to research. It uses a McDanel Zirco Protection Tube, open at both ends. Sample heats and cools in gas-tight tube, permitting use of many special atmospheres. McDanel Protection Tubes have high resistance to thermal shock—low coefficient of expansion. Special sizes! Write now! *Send for Bulletin P1-55.*

McDANEL Industrial CERAMICS

McDANEL

REFRACTORY PORCELAIN COMPANY
BEAVER FALLS, PENNA.

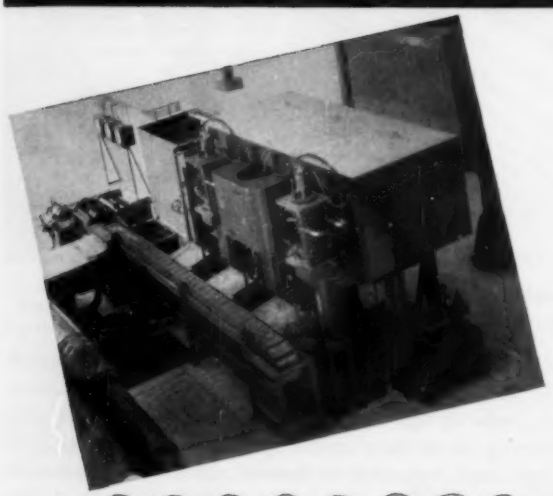
A Capital Investment with a Quick Payoff

Management thinks of a capital investment as the shifting of dollars from the current asset to the fixed asset account. Example -- purchase of machinery. If the purchase pays for itself in a short period of time, these expenditures can be thought of as "short term" investment. With our present tax laws, this means two dollars must be saved for every dollar invested.

Induction Heating fits this category ... a "quick payoff". Production savings start the day the equipment begins operation. This has been proved in hundreds of installations, one of which is detailed below.

Magnethermic Corporation
John A. Logan
President

MAGNETHERMIC INDUCTION HEATING SAVES DOLLARS



Gross Profit Increased $170,000 with Magnethermic Induction Heating Equipment

To preheat stainless steel billets, one plant replaced a conventional salt bath furnace with a Magnethermic Induction Heater at an investment of $50,000.

Result—an increase in gross profit of $170,000 per year, based on a twenty per cent production increase and a savings of $50,000 on maintenance.

Your inquiry will receive prompt, intelligent attention.

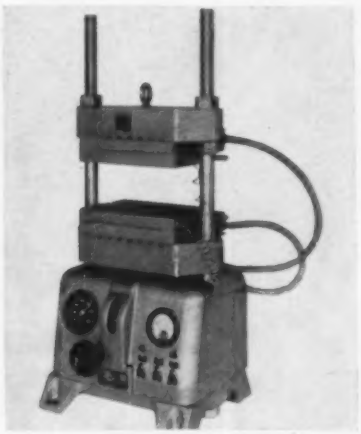
MAGNETHERMIC®
CORPORATION
3990 SIMON RD. • YOUNGSTOWN 7, OHIO

under examination is magnified 125 times and the readings in depth are made through fringe spacing of the contour lines. A camera attachment makes photographic records on 35 mm. film.

For further information circle No. 256 on literature request card, page 48-B.

Laboratory Press

The new hydraulic laboratory press which exerts a 12-ton pressure has been announced by Wabash Metal Products Co. The 7 by 10 in. platens are ground and electrically heated.

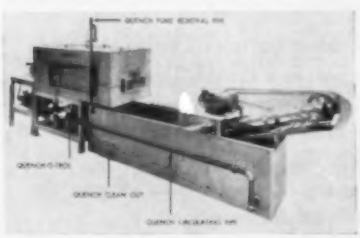


Temperature is closely controlled and ranges from 100 to 600°F. Element connections are shielded and ventilated. Columns are hard chromium plated for wear resistance and to assure alignment, and are rust proof.

For further information circle No. 257 on literature request card, page 48-B.

Furnace

Hevi-Duty Electric Co. has announced a new high temperature shaker hearth furnace for bright carburizing, cyaniding, and hardening at temperatures to 1900°F. This new furnace is available in three



standard sizes with capacities of 15 to 35, 35 to 75, and 75 to 150 lb. per hr. These furnaces provide automatic conveying of parts through the furnace chamber. Parts are heated in a protective atmosphere and dropped directly into a quench. Multiple zone temperature control provides controllable temperatures throughout the heating chamber.

For further information circle No. 258 on literature request card, page 48-B.

Laboratory Furnace

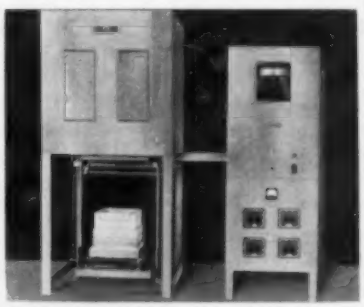
A new laboratory furnace designed to operate at temperatures up to

4500°F., has been announced by Harry W. Dietert Co. It has a nonmetallic heating element 2 in. i.d., and 16 in. long overall, with a usable length of 12 in. It is operated on any 220 volt, single phase, 100 amp. power supply, and will draw 13.4 kilowatts.

For further information circle No. 259 on literature request card, page 48-B.

Kiln

An elevator-type kiln, with a hearth which is raised and lowered by airplane cable controls and travels



in vertical guide rails, has been announced by the Electric Furnace Div. of Harrop Ceramic Service Co. The hearth may be moved sideways on horizontal external rails if desired. This model occupies a space 12 by 17 by 20 in. and provides for the firing of ceramic shapes, crucibles and other requirements of laboratory and pilot plant. The kiln operates at temperatures up to 2800°F., using 220 volts with 70 amp. input.

For further information circle No. 260 on literature request card, page 48-B.

UNIFORMITY

If you've had disappointing variations in monthly control of blast cleaning costs—try Malleabrasive.

Malleabrasive has the uniformity of metallurgical structure from one lot to the next that has leveled out the cost chart line in many of America's largest foundries and other metal working plants. Not only leveled—but lowered!

The full and complete Malleabrasive process itself—used by ourselves exclusively—provides a degree of uniformity unmatched in the metal abrasive field.

Whatever your blast cleaning job, Malleabrasive will do it well, and will repeat uniformly, from month to month. Write us for information.

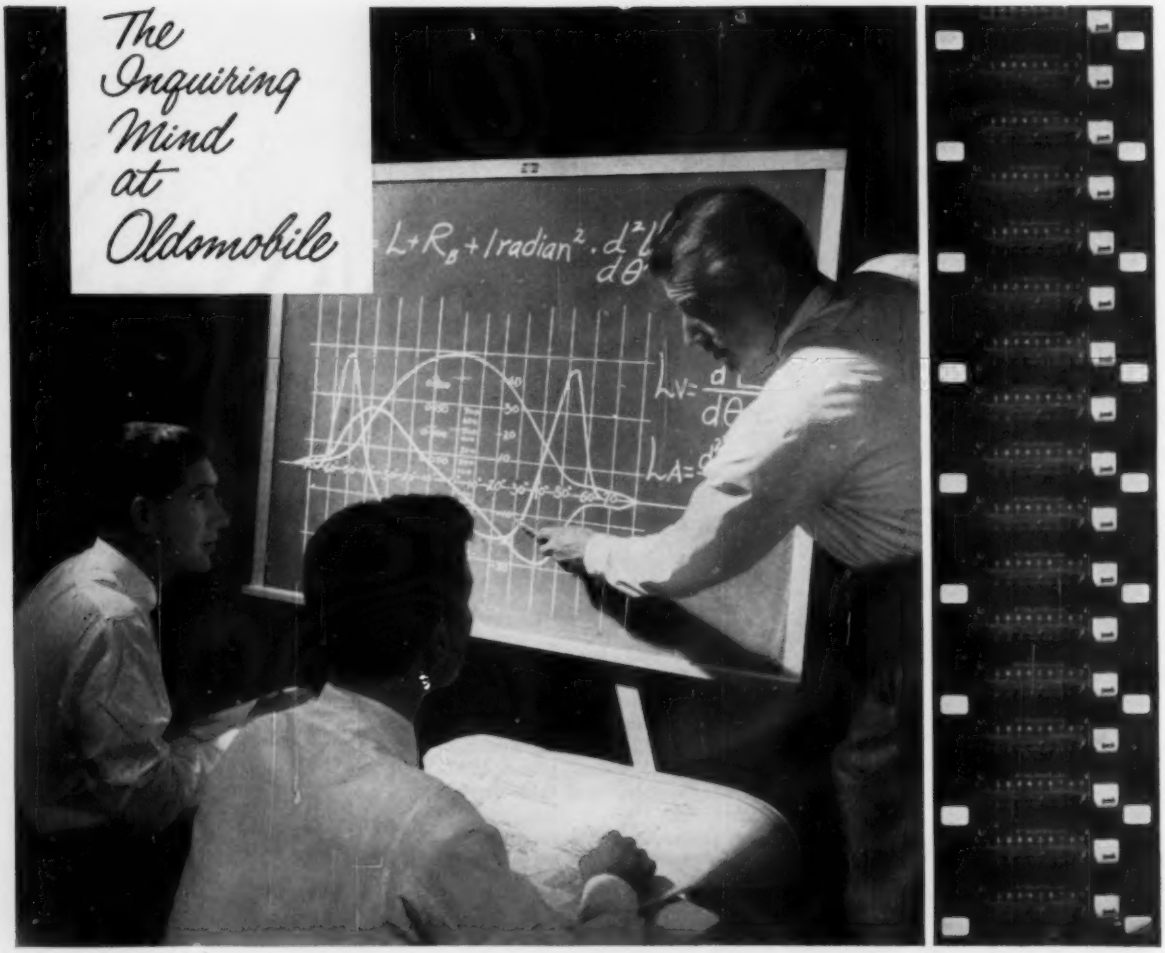
NOW IN 50 LB. BAGS

MALLEABRASIVE

THE GLOBE STEEL ABRASIVE CO.
Mansfield, Ohio

Sold by Pangborn Corp., Hagerstown, Md. and by many leading distributors of foundry supplies from coast to coast.

The Inquiring Mind at Oldsmobile



no. 1 OF A SERIES

FORMULA FOR A NEW BABY OF OURS

High speed photography helps Oldsmobile engineers translate the theory of camshaft design into practical reality.

Developing the "brains" of an engine—its camshaft—demands engineering skill of a high order, both in theory *and* practice. Advanced techniques of precision measurement guide Oldsmobile engineers in creating a profile design of optimum efficiency.

To determine exactly what happens in a valve train system, movies are taken at speeds up to 15,000 frames per second. The valve train under study is assembled in an engine block and driven by an electric dynamometer at precisely controlled speeds. A vernier scale, silver soldered to the valve spring retainer, is photographed as it moves with the valve's opening and closing.

Essentially, these photographs act as an analog computer. Analysis gives a plot of the actual "lift curve" of the camshaft—the exact linear movement of the valve at each degree of camshaft rotation. It tells at what points the valve opens and closes and also whether the valve lifter is following the cam as it should. This curve, compared to the theoretical lift curve is a definite point for refining to begin—to make sure that design theory will be production practice. With this exact and rapid technique of analysis, as many as 50 experimental camshafts may be tested before a final design is fixed.

The Inquiring Mind at Oldsmobile is never at rest in its attempt to build the best engineered car in the industry. Test drive the '58 Oldsmobile and you'll find it's the finest product in our 60-year history.

OLDSMOBILE DIVISION, GENERAL MOTORS CORP.

OLDSMOBILE

Pioneer in Progressive Engineering ...Famous for Quality Manufacturing

Large Stocks of One-Piece Elements. You get quick deliveries of Norton "Hot Rods" — on short notice. Also, most popular sizes of these CRYSTOLON heating elements — like the sizes shown in this section of the Worcester stockroom — are now made in the new, one-piece construction — with no welds. This assures greater strength and uniform straightness throughout each rod.

Greatly Increased Strength. Ever since they were first produced "Hot Rods" have been endorsed by users for outlasting other non-metallic heating elements up to 3 to 1. Today, the new one-piece rod, made in most popular sizes — and soon available in all sizes — is twice as strong in standard cross-bending tests.

One-piece "HOT RODS" now ready for immediate delivery...famous for long life and economy

CRYSTOLON heating elements bring you extra advantages for better performance and bigger savings*

Straighter Than Ever. Throughout the entire length of a one-piece, non-welded "Hot Rod" there isn't the slightest bulge in the surface. So, when you insert them into the openings of your furnace or kiln you can be sure there'll be no binding due to uneven diameters.

Scientifically Safe Packaging protects "Hot Rods" even more thoroughly than delicate household glassware or china. They're packed shockproof to reach you unbroken.

"Hot Rods" are a typical Norton Rx — an expertly engineered prescription for greater efficiency and economy in electric furnaces and kilns. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Most popular sizes are non-welded and interchangeable with your present rods.

You save in element costs because you use far less "Hot Rods." Also, their more uniform heating quality, due to their slow, evenly matched rate of resistance increase, helps you protect product quality and maintain a smooth production flow. For further facts on "Hot Rod" advantages send for booklet *Norton Heating Elements*, NORTON COMPANY, Refractories Division, 333 New Bond St., Worcester 6, Massachusetts.

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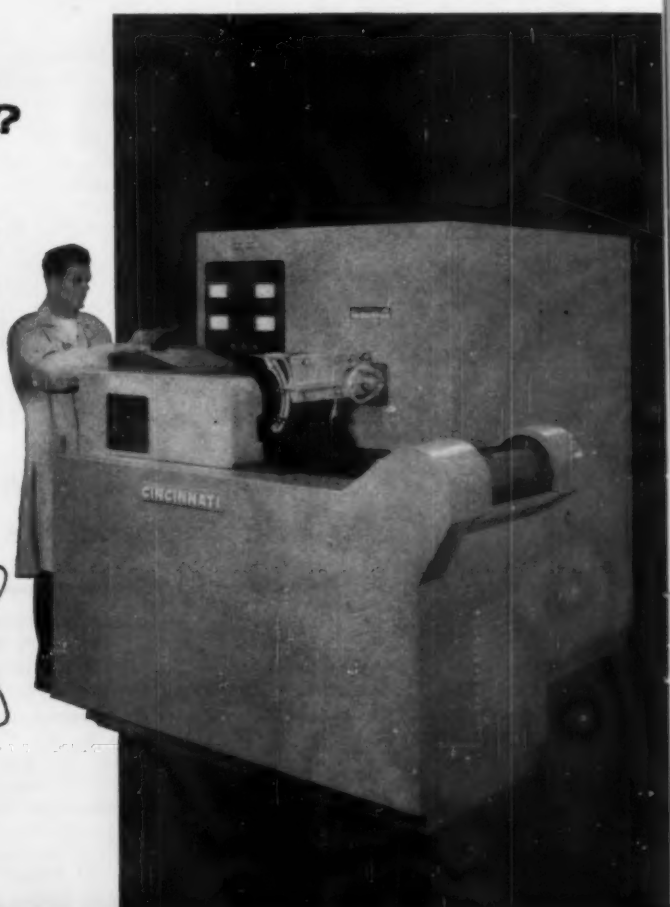
New CINCINNATI
flamatic®

In production, the machine shown uses multiple fixtures for selective surface hardening *1000 automotive rocker arms per hour.*

which CINCINNATI meets your selective surface hardening needs?

Your product components that require heat processing—such as selective surface hardening, annealing, brazing, tempering—can be Cincinnati-processed at a savings! New and versatile Cincinnati flame or induction heating machines can do the work you specify—and meet your cost-per-piece requirements-on high production quantities or varied, small-lot runs. Let a Process Machinery Division field engineer evaluate your needs. With the assistance of our extensive research laboratories and engineering facilities, he is ideally equipped to recommend the heat source and method that will be best and cheapest for you.

For machine descriptions and specifications, write for Flamatic Bulletin M-2015; Inductron Bulletin M-1993.



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Bulletin DH-460-B on machine models and capacities. *Campbell Machine Div.*

262. Air Washers
Bulletin No. 256 on acid-proof air washers for ventilation systems. Construction accessories. *Automotive Rubber.*

263. Alloy Castings
Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

264. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

265. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

266. Aluminum Bronze Alloys
20-page booklet on chemistry, physical properties and uses of aluminum bronze alloys in rolled, extruded and cast forms. *Ampco*

267. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

268. Aluminum Extrusions
Catalog of stock extrusion dies. *Jarl Extrusions*

269. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions, Inc.*

270. Aluminum Heat Treating
8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

271. Aluminum Melting
Folder on electric furnaces for the aluminum alloy foundry. *Ajax Eng'g*

272. Ammonia
8-page booklet on uses of dissociated ammonia in industry. Dissociation process and applications in bright annealing, furnace brazing, powder metallurgy, bright hardening. *Armour Ammonia Div.*

273. Annealing Furnaces
8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *Drever*

274. Atmosphere Furnace
12-page bulletin 1054 on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

275. Atmosphere Generator
Bulletin 439 on exothermic atmosphere generators for converting natural gas, manufactured gas, propane or butane. *W. S. Rockwell Co.*

276. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

277. Austempering
Bulletin No. 167 on mechanized salt bath installation for continuous heat treatment of farm tools. *Ajax Electric*

278. Belt Surfacing
12-page discussion of procedure and equipment for rough grinding of metallurgical specimens. Metal Digest V. 2, No. 5. *Buehler, Ltd.*

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44-page booklet, "Successful Applications of Thermostatic Bimetal," contains uses, formulas, calculations. *W. M. Chace*

280. Blast Cleaning
Complete information on Malleabrasive for cleaning and finishing. *Globe Steel Abrasive*

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Bulletin 227 on airless blast cleaning machine. Features of construction, sizes, how it operates. *Pangborn*

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Specifications and instructions 300 on turbo blowers describe installation, maintenance, assembly. *North American Mfg.*

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New 8-page bulletin on carbon and graphite for high temperature applications. Pertinent aspects of manufacturing process. *Speer Carbon Co.*

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Bulletins A-1 and A-2 on liquid carburizing. Equipment, bath make-up and maintenance, cyanide analysis. *Park Chemical*

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16-page booklet on gray iron, ductile iron, special iron and steel castings. Physical property data. *Howard Foundry Co.*

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10-page Bulletin 90 on precision etching of metal parts by chemical and electrolytic means. *Superior Tube*

289. Chemical Processing
16-page manual on chemical processing compounds tells of their uses in 57 metalworking operations. *Turco Products*

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Data sheets on Luster-on 50 conversion coating for manual or automatic plating. Bath make-up, operating conditions, typical cycle. *Chemical Corp.*

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6-page Bulletin 10 on extrusions of two combined metals. Combinations available, techniques of production. *Nuclear Metals*

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Report on service life of woven wire conveyor belts operating at temperatures of 2050° F. *Cambridge Wire Cloth Co.*

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New 12-page booklet on Tantung solid tool bits, tipped tools, cut-off blades. Properties and analysis of Tantung. How to braze and grind it. *Vascoloy-Ramet*

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Folder on automated degreaser. Cleaning and solvent cycles described. Features of equipment. *Detrex*

308. Degreasers
Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

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310. Descaling Stainless Steel
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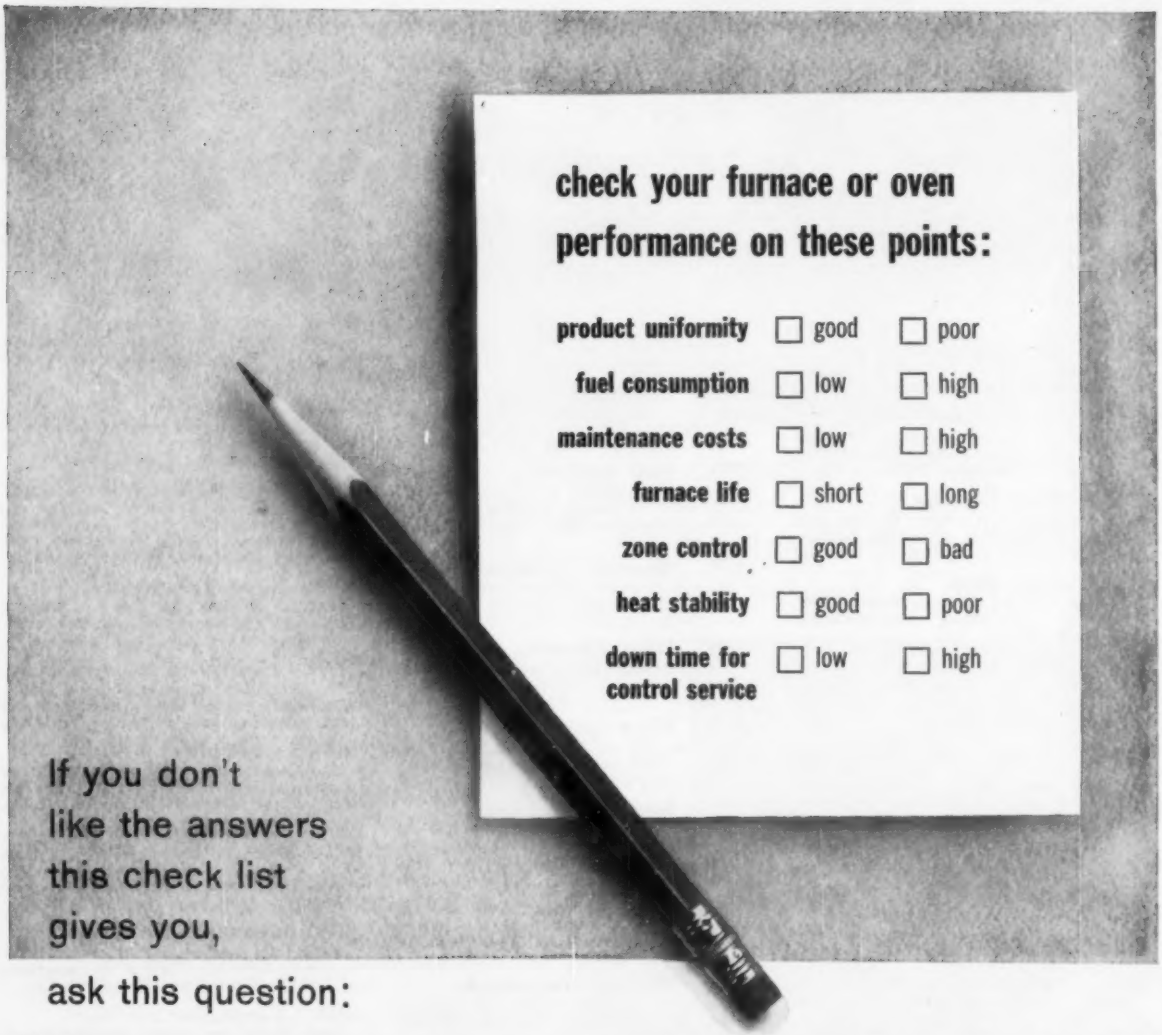
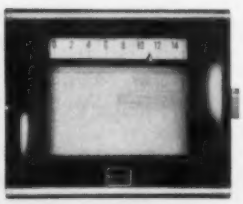

check your furnace or oven
performance on these points:
product uniformity ☐ good ☐ poor
fuel consumption ☐ low ☐ high
maintenance costs ☐ low ☐ high
furnace life ☐ short ☐ long
zone control ☐ good ☐ bad
heat stability ☐ good ☐ poor
down time for control service ☐ low ☐ high
If you don't like the answers this check list gives you,

ask this question:

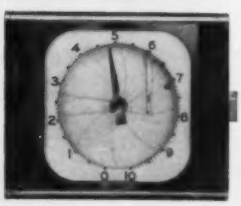
"Are my furnace controls obsolete?"

Strip-chart model



BRISTOL DYNAMASTER* ELECTRONIC PYROMETER CONTROLLERS

Round-chart model



Outmoded instruments can cost you money, lower product quality, and cut output of any furnace or oven.

New Bristol ideas are revolutionizing many older concepts of automatic control. *Bristol's great strides in electronic potentiometer development have made obsolete many instruments only a few years old.*

New product developments and production methods are placing new and unusual demands on furnace instruments and controls today.

That's why it pays to find out about the latest Bristol engineering developments before you buy another instrument or control. Take Continuous Standardization, for example—a feature you'll want on *your* next pyrometer controller. This exclusive Bristol feature, found only on Dynamaster* Pyrometers, eliminates dry cells but retains the accuracy-insuring standard cell. There's no interruption to control for standardization; no batteries to replace.

Continuous Standardization is just *one* recent Bristol development in the field of pyrometry and temperature control. To find out more, write: The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.

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315. Electric Furnaces
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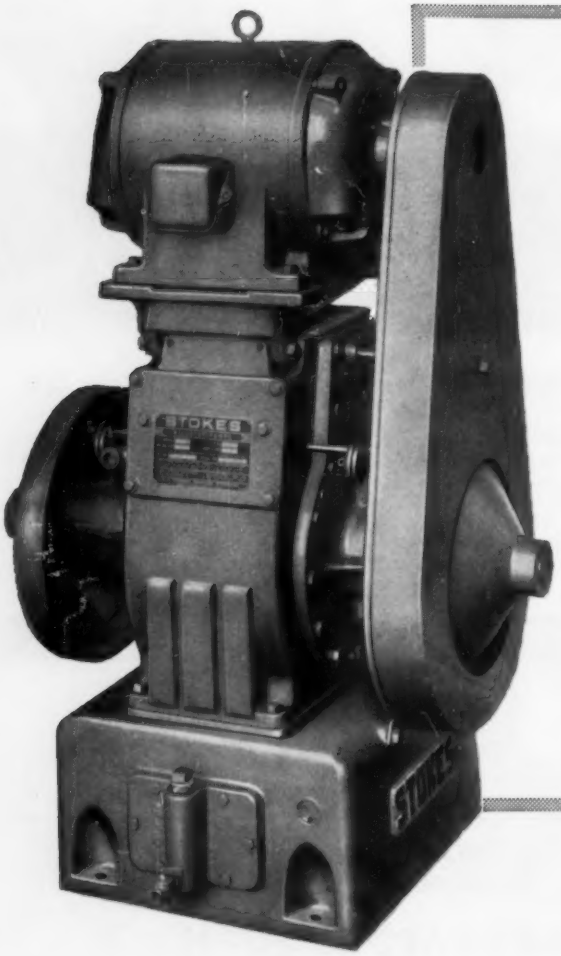

VERTICAL DESIGN

vacuum pump saves you floor space

If floor space for your vacuum system installation is a problem, here's an "assist" from Stokes. Special Stokes vertical design cuts floor space requirements. For example, the 130 cfm Model 212 Microvac measures less than 3 feet on a side . . . makes your entire set-up smaller.

And together with these features of compactness, you get a 15% increase in pumping capacity . . . at no increase in price. In this way, Stokes Microvac pumps measure up as the standard of comparison for reliable, low-cost performance.

Here's what you get with the Microvac line:

- Minimum maintenance—mechanical face seal eliminates oil leakage at shaft. No stuffing boxes. Fully automatic lubrication.
- Wide pressure ranges—new exhaust valve design assures trouble-free operation during extended pumping periods, in the high pressure range.
- Dirt troubles prevented—intake screen filter traps dirt, scale and other damaging solids.
- Added protection—new oil filter in the line supplies extra protection to bearings and shaft seal.

Microvac pumps give you the high efficiency you want . . . used separately or as roughing pumps with diffusion or booster pumps. Write for catalog 752, "Stokes Microvac Pumps for High Vacuum"; Booklet 755, "How to Care for Your Vacuum Pump" . . . or call your nearest Stokes office to find out how we can help you solve your particular vacuum application problem.

Vacuum Equipment Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

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National-U.S. Radiator Corporation

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JOHNSTOWN, PA.

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332. Furnaces
12-page reprint on design, construction and application of chain belt conveyor furnaces. *Electric Furnace Co.*

333. Furnaces
Bulletin 205 on gas and electric industrial furnaces. Vitreous enameling model, stress relieving furnace, pit-type, carburizing and nitriding furnace, and others. *A. F. Holden*

334. Furnaces
Data on radiant aluminum die casting furnaces. *J. A. Kozma Co.*

335. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

336. Furnaces
Lists of surplus furnaces for sale. *Joe Martin Co.*

337. Furnaces
Folder describes complete set up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

338. Fused Quartz
New brochure on fused quartz and silica for use in furnaces and laboratory equipment. Properties and how they are formed into usable products. *Amersil Co.*

339. Gold Plating
8-page paper gives bath composition, equipment and operating conditions, and metallurgical characteristics of 24K gold plate on various base metals. *Sel-Rex*

340. Gold Plating
Folder gives data on plating to obtain a hard bright gold finish. *Technic, Inc.*

341. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

342. Hardness Numbers
Pocket-size table of Brinell hardness numbers incorporating other tabular information. *Steel City Testing*

343. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

344. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

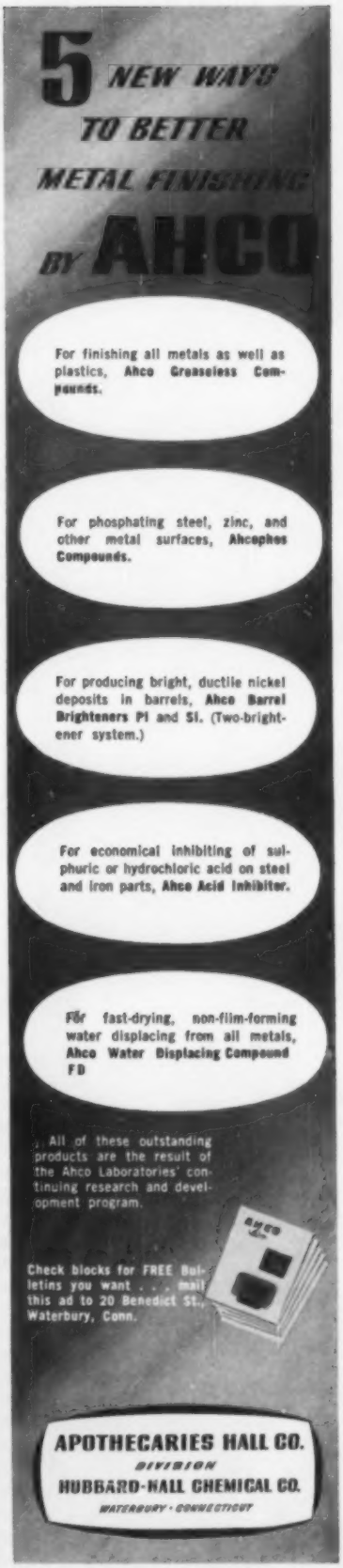
345. Hardness Tester
Bulletin A-16 on micro-reflex hardness testers. Loads to 3000 gr. Zeiss optical system. *Gries Industries, Inc.*

346. Hardness Tester
Data on portable hardness tester with Rockwell and Brinell scales. *Mechanical Devices*

347. Hardness Tester
4-page bulletin on portable metal hardness tester for any shape or metal. Ranges, features. *Newage Industries*

348. Hardness Tester
Catalog 72-1 on Leitz miniload tester for Vickers and Knoop hardness tests. *Opto-Metric Tools, Inc.*

349. Hardness Tester
Data on hardness testing scleroscope


5 NEW WAYS TO BETTER METAL FINISHING BY AHCO
For finishing all metals as well as plastics, Ahco Greaseless Compounds.
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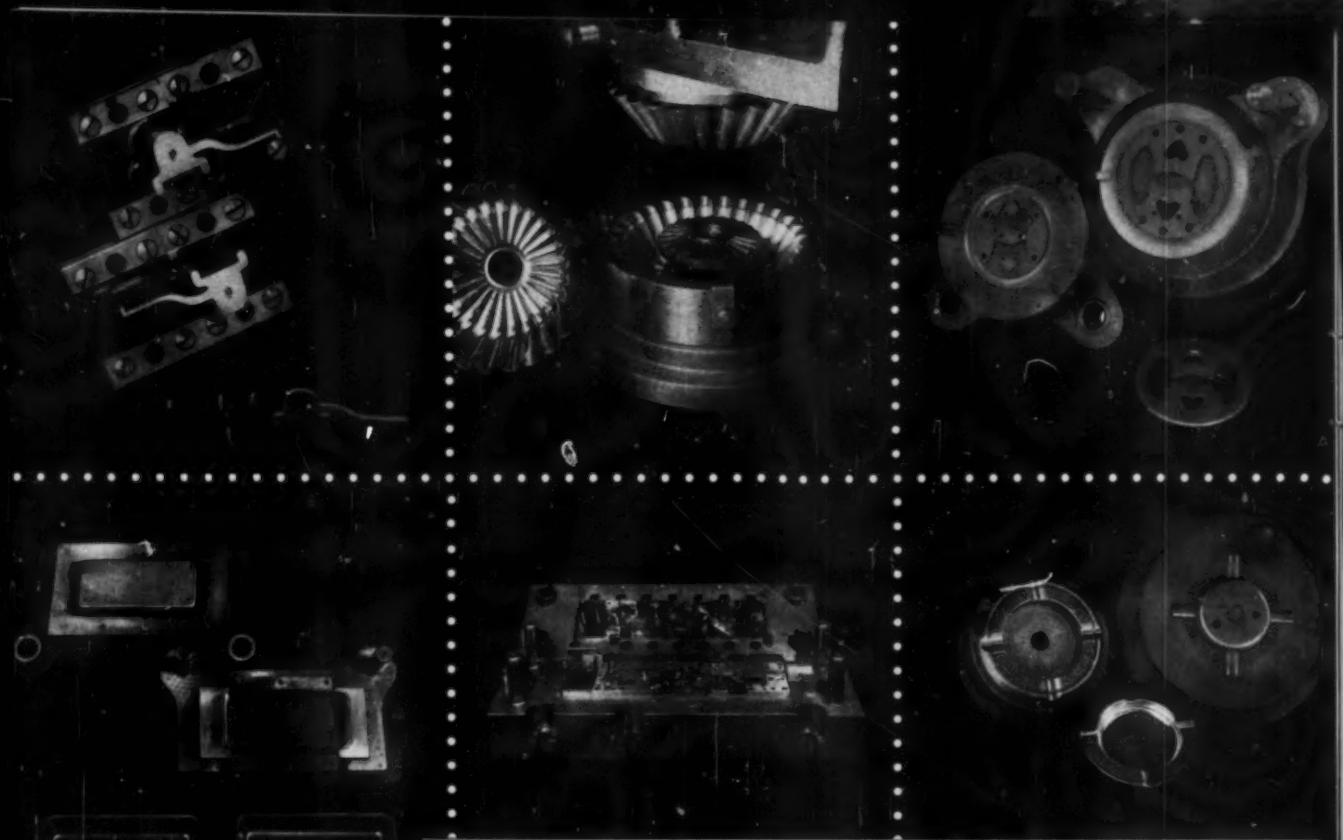

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NON-SHRINKABLE

oil hardening die steel

for every job in the shop

COLONIAL NO. 6—Non-Shrinkable is a general purpose die steel worth having in stock at all times. It pays off in reliable performance on the widest variety of jobs. It pays off in simplified inventory—you can carry *one* steel in the sizes you usually require, because you can make almost anything with Colonial No. 6. Do you have full data on this easy-machining, safe hardening, simple to heat treat die steel? Write us for Colonial No. 6 facts you can use, and the direct help of a trained Vanadium-Alloys sales engineer.

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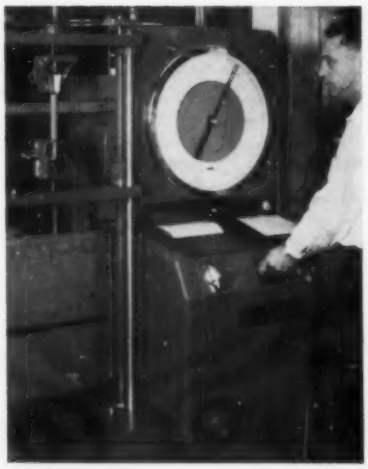
PHYSICALLY FIT



Exacting physical requirements such as fatigue resistance, tensile strength and drawing properties are easily met by SOMERS, where complete facilities include a modern laboratory equipped for chemical, electrical and performance testing of all SOMERS THINSTRIP—both in process and before shipping.

The latest electronic gages, controls and other precision instruments guarantee uniform quality every time in nickel and its alloys from .020" and copper and its alloys from .010", both down to .000175".

Special requirements are "run of the mill" for SOMERS. Write for confidential data blank or field engineer.

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with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

350. Hardness Testers

20-page bulletin on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument*

351. Heaters

Bulletin on immersion heaters for electroplating solutions. *Glo-Quartz*

352. Heat Resistant Alloy

10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. *Rolled Alloys*

353. Heat Treating

New brochure on design and construction of new Model B heat treating units. *Ipsen*

354. Heat Treating

Monthly bulletin on used heat treating and plating equipment available for immediate delivery. *Metal Treating Equipment Exchange*

355. Heat Treating Aluminum

New Bulletin SC-171 on furnaces, soaking pits, annealers, batch units for heat treating, melting, investment casting aluminum and other light alloys. *Surface Combustion*

356. Heat Treating Ammonia

24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

357. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

358. Heat Treating Fixtures

12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

359. Heat Treating Furnaces

32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

360. Heat Treating Furnaces

Folder on industrial furnaces. Continuous designs. Insulation. *Pacific Industrial*

361. Heat Treat Pots

Catalog on pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Industrial Combustion Div.*

362. Heat Treat Pots

6-page folder gives stock shapes and sizes. Tips on installation and use. *Electro-Alloys Div.*

363. High-Alloy Castings

16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

364. High-Strength Steels

29-page discussion on progress being made toward higher strength alloy steels. Methods which increase strength of nickel-chromium-molybdenum alloy steel. *International Nickel Co.*

365. High-Strength Steel

26-page booklet on properties, uses, applications of high-tensile low-alloy steel. *Jones & Laughlin*

366. High-Strength Steel

Folder on medium manganese copper-bearing high strength steel. Properties. Corrosion resistance. *Youngstown Sheet & Tube*

367. Identifying Stainless

Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

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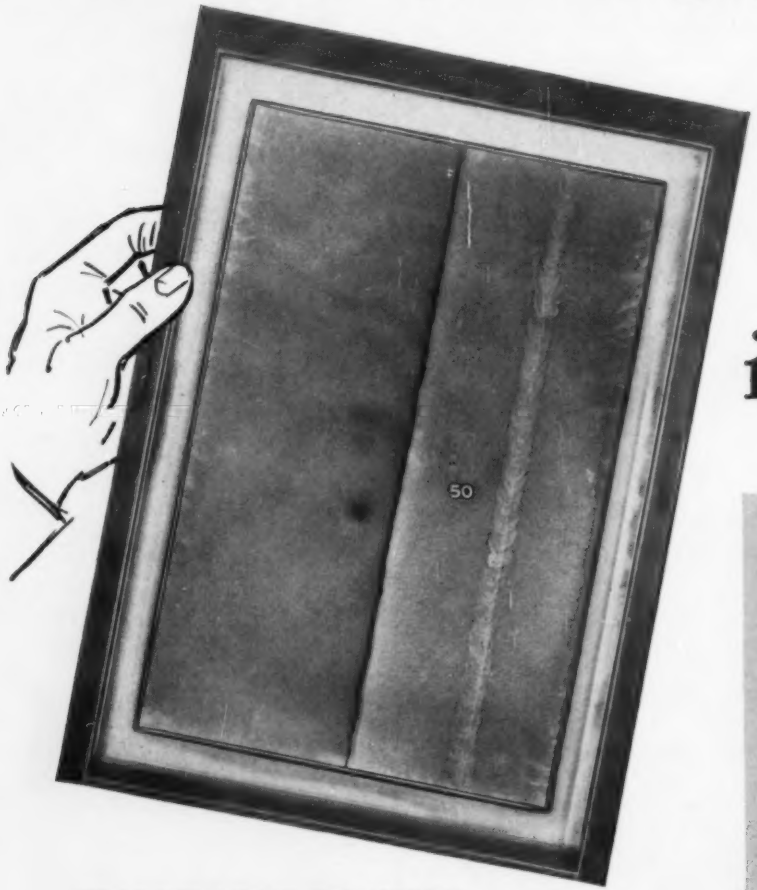
100% x-ray inspection



XERORADIOGRAPHY

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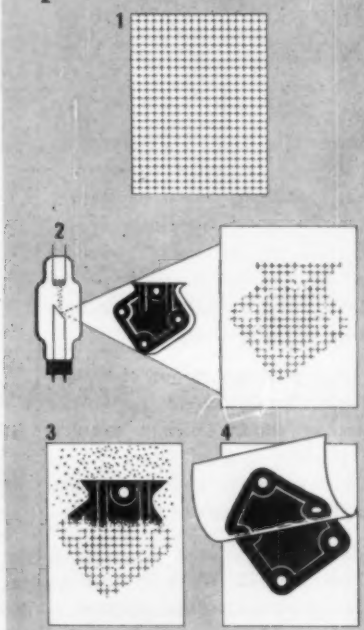
If you want to perform 100% inspection of light-metal or thin-section ferrous components—xeroradiography (zero-radiography) is *the* preferred method. *Within one minute after exposure, you can view results* well within the accepted 2% sensitivity. Corrections can be made immediately after a flaw is detected.

As for cost saving — xeroradiography requires a less expensive installation. There's no darkroom . . . no x-ray film. Metal plates are re-usable.

If you've been wanting to institute 100% x-ray inspection, General Electric now offers you a process that overcomes previous time and cost factors. Ask your G-E x-ray representative to demonstrate xeroradiography's possibilities for you. Or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, for Pub. AS-24.

How xeroradiography process works...



1. Aluminum plate, coated with photo-sensitive selenium, receives positive charge which is lost when exposed to x-rays.

2. X-rays penetrate specimen as in conventional radiography. Charge on plate "leaks" away in direct proportion to the degree of x-radiation.

3. Negatively charged powder from spray gun adheres to positively charged area. Density varies with amount of charge. Image can be viewed directly, copied on film record, or transferred to paper.

4. Print can be made by pressing special paper on plate by rollers. Powder from plate is transferred, giving a positive image which is fixed permanently by applying heat. Plate is cleaned for re-use.

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368. Immersion Heating

4-page bulletin H-11 on correct selection, sizing and installation of equipment for immersion heating. *Eclipse Fuel Eng.*

369. Induction Heating

20-page booklet, "Dr. Northrup's Fireless-Wireless Furnace", gives story of development of high-frequency induction heating. *Ajax Electrothermic Corp.*

370. Induction Heating

Need for ground detectors on high frequency induction furnaces discussed in Inducto Metal Melting Newsletter, No. 5. *Inductotherm*

371. Induction Heating

12-page bulletin gives descriptions, technical data on various sizes. Water systems diagramed and standard accessory equipment. *High Frequency Heating Div., Lindberg Engineering*

372. Induction Heating

Bulletin on heat treating, joining and hot forming. Charts on current penetration and equipment for heating steel above curie point. *Magnethermic Corp.*

373. Induction Heating

8-page bulletin on high-frequency motor-generator sets for induction heating. *Ohio Crankshaft*

374. Induction Heating

36-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

375. Instruments

6-page folder on mechanical force gage for measuring pressure, tensile or torque. *W. C. Dillon*

376. Instruments

32-page Catalog 20-10 on electronic self-balancing instruments for indicating, recording, controlling. Instruments described and diagrammed. Principles of operation. *Foxboro*

377. Instruments

New Bulletin D on thermowells. Types and alloys in which they are available. Specifications in chart form. *Thermo Electric*

378. Iron Powders

32-page book on design and powder metallurgy for iron powders. Tables, graphs of properties. *Antara Products Div.*

379. Laboratory Equipment

New bulletin on cutting test specimens describes methods for different types of metals. Price list. *Sieburg Industries*

380. Laboratory Furnaces

Bulletin No. 310 on high temperature electric tube furnaces for laboratories. *Burrell*

381. Laboratory Instruments

20-page booklet on gage laboratory instruments. Layout of a gage laboratory. Description of each instrument. *Sheffield*

382. Laboratory Mill

4-page reprint on rolling mill for laboratory studies, which may be operated as a 2-high, 3-high or 4-high mill. *Fenn Mfg.*

383. Lab Test Dies

Complete information on multi-motion laboratory test specimen dies. *Haller*

384. Leaded Steels

16-page booklet on basic characteristics, mechanical properties and workability of leaded steels. Case histories. *Copperweld Steel Co.*

385. Leak Detector

Data sheet on Model 4902 leak detector includes description, operation, accessories. *NRC Equipment Corp.*

386. Lubricant

Bulletin 426 on use of colloidal graphite for forging, wire drawing, piercing, drawing, extrusion and other metalworking operations. *Acheson Colloids*

387. Lubricant

Bulletin 103A on fringe area lubrication with molybdenum disulfide lubricants for extreme bearing pressures and all temperatures. *Alpha Molykote*

388. Machining Alloy Steels

24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

389. Magnetic Alloys

Article on use of vanadium in magnetic alloys. Comparison of Supermendur and Permendur. Vancoram Review, Fall 1957. *Vanadium Corp.*

390. Malleable Castings

Continuing series of information bulletins covering latest techniques and practices in modern malleable casting. *Malleable Founders' Society*

391. Marking Machines

Data on various types of marking machines from bench mounted machines for light duty marking to machines capable of marking at up to 6 tons table pressure. *Jas. H. Matthews & Co.*

392. Marking Metal

Bulletin on electromark process. Equipment. Operating instructions. *Electromark*

393. Melting

8-page booklet gives suggestions on how to operate a melting furnace. *Campbell-Hausfeld*

394. Melting Furnaces

28-page catalog and new folder on

(Continued on page 48-A)

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THE STROMAN ELECTRIC RESISTANCE FURNACE

For delivering quality melted metal faster to die casting and permanent mold machines this new Stroman Electric cannot be beat. It is designed for holding aluminum and does it so perfectly right up to the highest of casting temperatures. It has an absolutely quiet bath with no turbulence and is noiseless in operation. Dross formation is extremely low and metal may be held overnight or over the week-end with no appreciable damage or loss. Service is so simple as the roof of the furnace is removable for cleaning and maintenance.

This Stroman Electric Furnace comes as a complete package of Control Panel, Transformer and Furnace, delivered, ready to operate on 220 V or 440 V — 3 phase 60 cycle AC, with capacities of 500-800-1500 & 2000 pounds.

This Stroman Furnace has many, many more exclusive features that make it the most efficient and economical Electric Resistance Furnace you can buy. Why not have a chat with one of our metallurgists and let him show you how one of these furnaces can benefit your plant. Drop a line to-day . . . Do it now!

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...the improved Foxboro M/41A Indicating controller

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The M 41A Controller offers a sharp, fast on-off action, or smooth proportional control action easily adjustable from .25% to 25%. It employs the famous Model 40 controller movement — free from backlash, lost motion, and friction. This is a rugged, low-cost, compact controller using standard M/40 parts *throughout* . . . easy to get at . . . easy to service.

For control of simple processes—temperature, pressure, liquid level, or humidity — it will pay you to investigate the convenience and the precise, reliable performance of the Foxboro M/41A Indicating Controller. Write for Bulletin 5A-13A.

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- Longer Scale — 5" effective length.
- Snappy "On-Off" Control Action on measurement change of only ⅛ of 1% scale.
- Alternate Proportional Action adjustable from ¼ of 1% to 25%.
- "Permaligned" Precision Controller Movement — Exclusive Self-Aligning Ball-Linkage—Non-Backlash Vernier Index Drive
- Simple Rugged Construction—All Parts Easily Accessible

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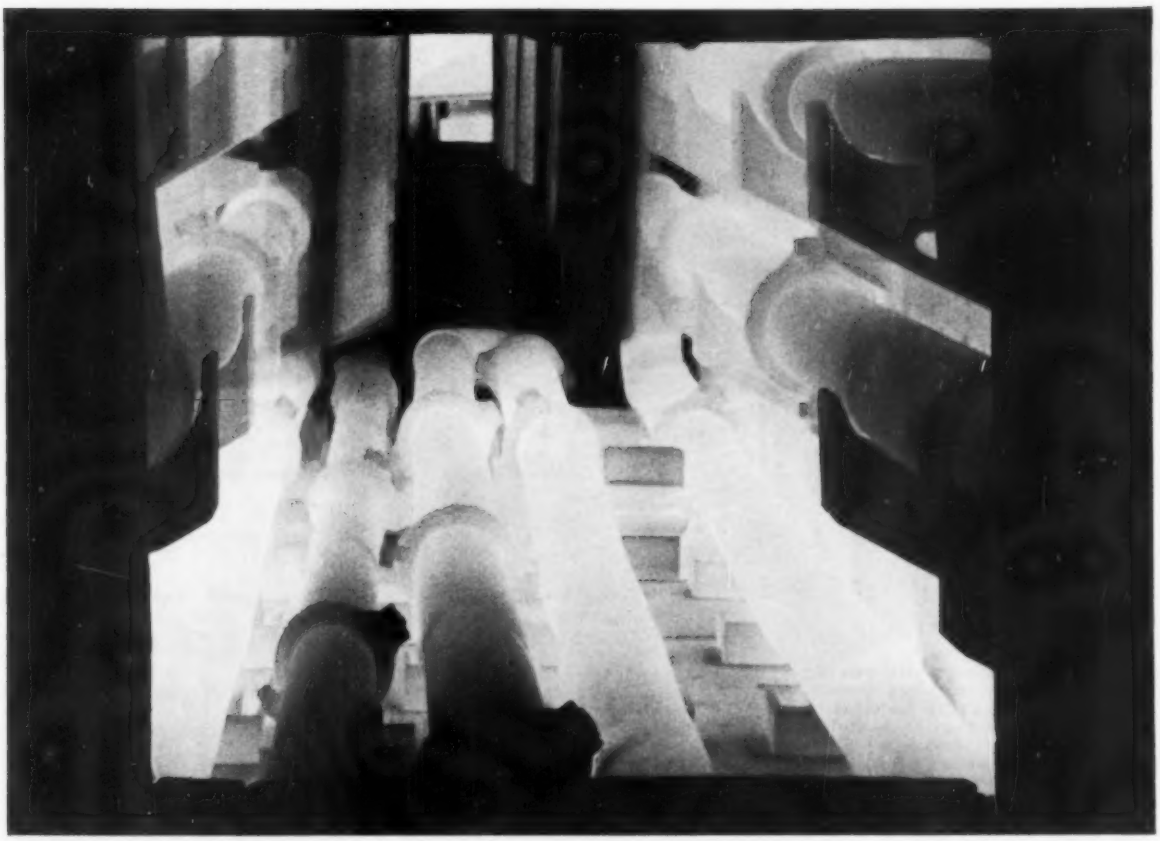
FOXBORO REG. U. S. PAT. OFF. INDICATING CONTROLLERS



NEW!

Enameling furnace radiant tubes made of Inconel!

Installation at Newark Stove follows in-furnace tests indicating a 4-time boost in tube life

These Inconel* nickel-chromium alloy radiant tubes are expected to serve four times as long as conventional tubes; an expectation solidly based on a long-term in-furnace test.

Back in 1951, Newark Stove installed a sample Inconel alloy tube in the "hot" leg of one U-section. It lasted six years. Best previous life was one-and-one-half years.

As early as 1954, however, it became clear that Inconel alloy could reduce radiant tube replacement by an impressive figure. So Newark equipped the "hot" legs of one entire furnace with Inconel alloy tubes. (The *long* tubes shown above.)

The record to date and (as you can see) the appearance of these tubes strongly reinforces Newark's six-year life-expectancy estimate.

Other Savings

Other important savings attributed to the new Inconel alloy tubes include less down-time, 50% lower maintenance and material costs, and reduced furnace heating costs . . . the latter because of a 1/16-inch reduction in tube wall thickness (and hence lighter weight).

Temperatures run from 1300° to 1500°F

At these temperatures and on up, in many cases, to 2000°F Inconel alloy has excellent resistance to oxidation and corrosion from combustion gases. It also retains high strength and withstands thermal shock. Fabricating and welding properties are good, too.

Inconel alloy may help you improve the service life of your high temperature equipment and fixtures. For help in looking into it, call on Inco's High Temperature Engineering Section. They'll be glad to give you an assist.

*Registered trademark

The International Nickel Company, Inc.

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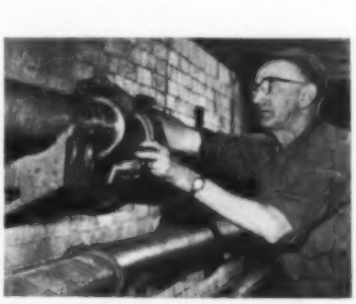
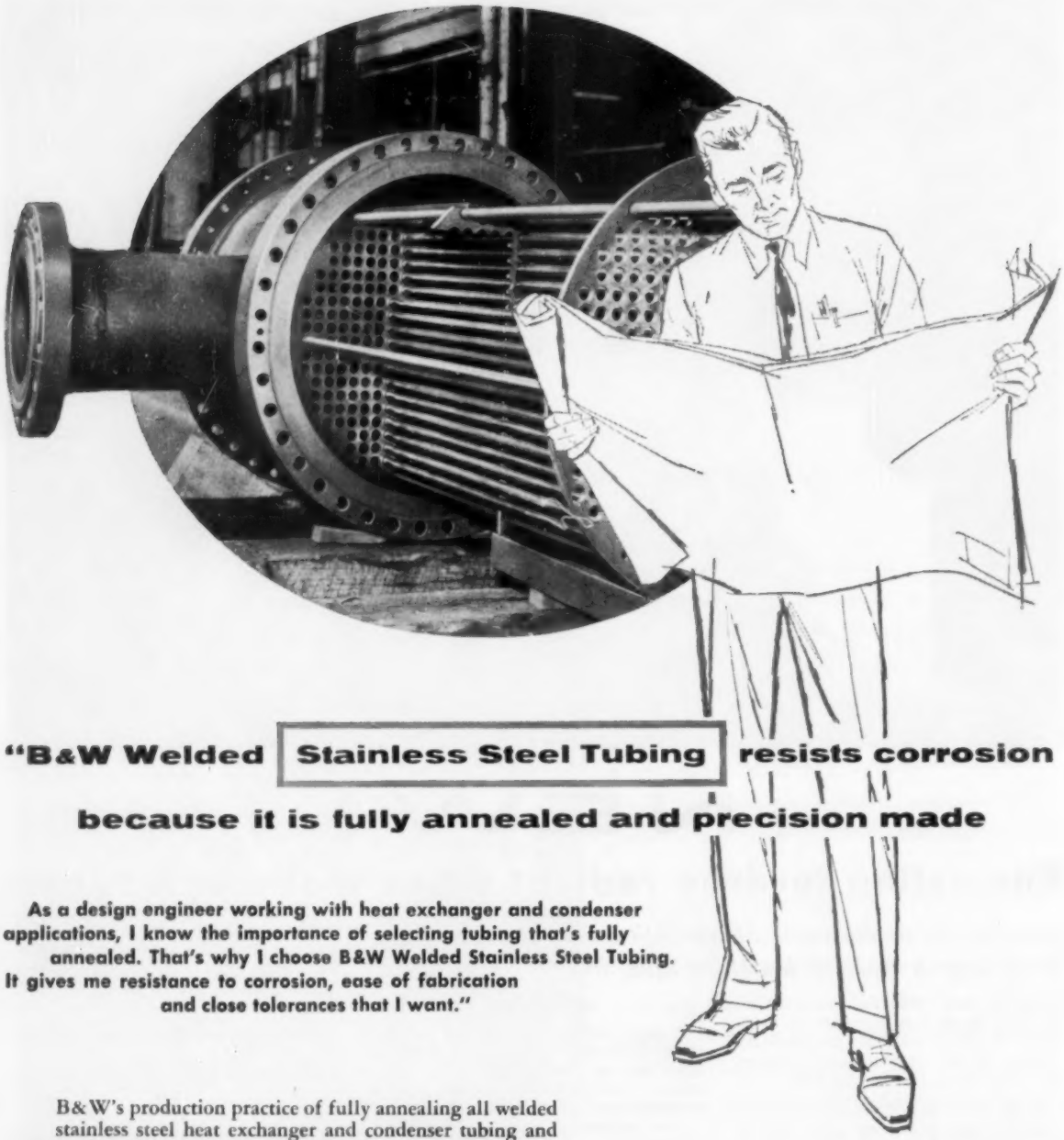


4-times-the-life Inconel alloy radiant tubes are clamped in place at Newark Stove Company plant.

INCO NICKEL ALLOYS



"B&W Welded Stainless Steel Tubing resists corrosion because it is fully annealed and precision made

As a design engineer working with heat exchanger and condenser applications, I know the importance of selecting tubing that's fully annealed. That's why I choose B&W Welded Stainless Steel Tubing. It gives me resistance to corrosion, ease of fabrication and close tolerances that I want."

B&W's production practice of fully annealing all welded stainless steel heat exchanger and condenser tubing and performing a minimum amount of cold work after heat treatment achieves the ideal condition of maximum general corrosion resistance and close size tolerances. This provides ease of fabrication and threading of tubing through baffles and tube sheets and minimizes the possibility of failures in service due to combinations of stress and corrosion.

For further information, call Mr. Tubes, your nearest B&W representative—he can help you solve any tubing problem—or write for Bulletin TB-415. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

B&W TUBULAR PRODUCTS DIVISION

TA-8007-PG-2

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

(Continued from page 45)

Heroult electric furnaces. Design, types, sizes, capacities, ratings. *American Bridge*

395. Metal Crystals
Bulletin on large single metal crystals and polycrystals. *Flow Corp.*

396. Metal Treatment
Booklet on metal treating and finishing products. *John Swift Chemical Co.*

397. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

398. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

399. Mixers
New Bulletin 581 on high speed, vertical and batch-type mixers. *Conn & Co.*

400. Molybdenum Borides
6-page bulletin on applications, chemical, physical and mechanical properties of refractory molybdenum borides. Preparation of compounds. *American Metal Climax*

401. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

402. Nonferrous Forgings
34-page booklet on brass, bronze and aluminum forgings. How they are made, composition of alloys, tolerances. *Mueller Brass*

403. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

404. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

405. Oils
4-page bulletin on industrial products lists lubricants, hydraulic oils, cutting oils, quenching and tempering oils. *Sun Oil*

406. Phosphor Bronze
Facilities for rolling, cleaning, welding, trimming and treating phosphor bronze. *Rolling Mill Div., Miller Co.*

407. Photographic Films
Catalog of motion picture, radiographic and industrial films, photographic papers and luminescent chemical products. *DuPont*

408. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

409. Plating
9-page bulletin on copper fluoborate bath for printed circuits. Bath composition, make-up, and control for copper and tin plating. *Baker & Adamson*

410. Plating
Data and specification sheet covering tin plating a wide range of nonferrous thin strip metals. *Somers Brass Co.*

411. Powdered Iron
Properties of Plast/Iron with and without copper. *Plastic Metals Div.*

412. Powdered Metals
24-page catalog 815 on 37 different models of powder metal presses. *F. J. Stokes*

413. Powder Metallurgy
16-page booklet on advantages and disadvantages of process, design data, materials used. *Reese Metal Products Corp.*

414. Powder Metallurgy
Technical literature on high-density sintered metal parts. *Supermet Div., Globe Industries*

415. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

416. Precision Casting
12-page book on alloy selection and design for investment casting. *Arwood Precision Casting*

417. Quenching
Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

418. Radiation Badges
Data on badges which record exposures to radiation. *Picker X-Ray Corp.*

419. Recirculating Furnace
Bulletin on continuous-type recirculating furnace shows design of furnace, its operation and advantages. *Industrial Heating Equipment Co.*

420. Refractories
New 24-page manual on mortar preparation and general instructions. Bibliography. *Lumnite Div.*

421. Refractories
12-page catalog shows properties of impervious recrystallized alumina and impervious mullite. Shapes into which each is fabricated. *Morganite, Inc.*

422. Refractories
24-page booklet on how refractory grain is produced. Chemical and physical charactistics, sizes available, applications. *Norton*

423. Refractories
New 24-page pocket-size booklet on selection of castables, cements, ramming mixes and patches. *Chas. Taylor Sons Co.*

424. Residual Stresses
32-page, pocket-size booklet on residual stresses in cold-finished steel bars and their effect on manufactured parts. *LaSalle Steel*

425. Resistance Alloy
New 16-page catalog on 60-16 nickel-chromium-iron alloy. Heating element design factors. *Hoskins Mfg. Co.*

426. Rust Preventive
Bulletin 22 on water-soluble rust preventive for cast iron and steel. *Production Specialties*

427. Salt Bath Carburizing
5-page booklet on liquid carburizing with advantages and disadvantages of the salt bath process. *American Cyanamid*

428. Salt Bath Equipment
8-page bulletin on Kolene descaling, deseanding, and graphite removal processes. *Kolene Corp.*

429. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

430. Seamless Tubing
Alloy Letter 290 on high temperature properties of Croloy 16-13-3 seamless tubing. Short time tensile and creep rupture tests at temperatures to 1500° F. *Babcock & Wilcox Co., Tubular Products Div.*

431. Slug Caster
Data on automatic slug caster for producing aluminum slugs for forging and impact extrusion. *Stroman Furnace*

432. Sodium
28-page booklet on using sodium in dispersed form tells how dispersions are prepared and handled, and their advantages. *Ethyl Corp.*

433. Spring Steels
6-page folder gives applications, materials, finish and size range. Analyses. *Sandvik Steel*

434. Stainless Steel
New 44-page manual on stainless steel products for architects and builders. Where to buy factory-made components. *American Iron and Steel Institute*

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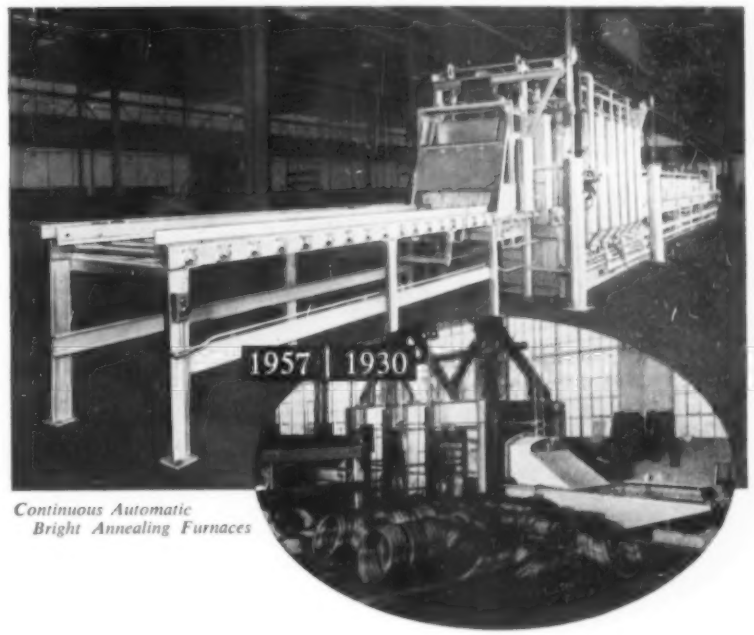

Continuous Automatic Bright Annealing Furnaces

Yesterday's Pioneers . . .

Today's LEADERS

Almost 30 years ago, Holcroft was leading the way in the development and refinement of continuous automatic heat treating furnaces. The furnace shown in the oval, for example . . . an oil fired, muffle-type, steam atmosphere furnace for bright annealing copper wire . . . was built back in 1930 for a prominent Canadian wire and cable manufacturer.

Holcroft's position of leadership, well established then, remains unchallenged now . . . and Holcroft's present-day version of a continuous automatic bright annealing furnace (illustrated above) perhaps best explains why. For this modern furnace bright anneals brighter, cleaner, faster. It features radiant tube heating, controlled exothermic atmosphere, complete mechanical handling, a temperature regulated cooling tunnel . . . and it will handle 2,500 pounds of copper and brass tubing per hour, straight or coiled, in sizes from tiny capillary to 3″ O.D. In a word, it's *all Holcroft*, and in a heat treat furnace there's nothing finer. You'll find that out for yourself when you make your next furnace a Holcroft.

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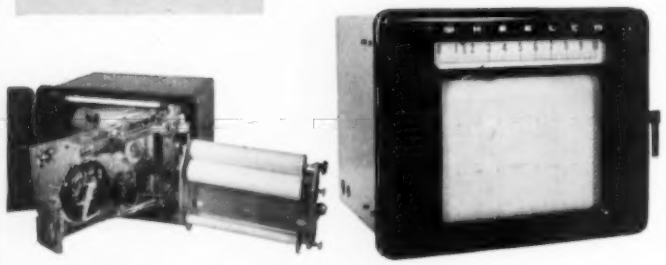

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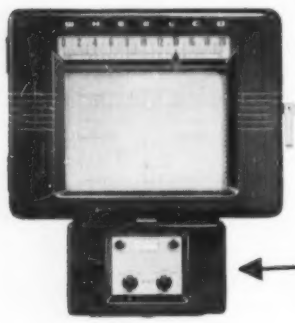
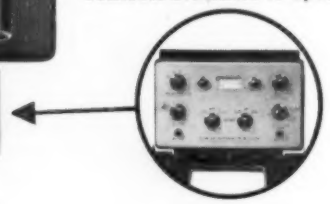


Automatic Reset for Recording Controllers—available with Series 8000 instruments for demanding processes where small capacitance requires wide proportional settings and where offset cannot be tolerated. Tamperproof cover protects all adjustments, leaves necessary controls available to operator.



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48-B

435. Stainless Steel
New 28-page booklet on properties and applications of 17-4PH and 17-7PH stainless. Fabricating procedures. *Armco Steel*

436. Stainless Steel
8-page catalog of stainless sheet and plates. Analyses, finishes, sizes. *Eastern Stainless Steel Corp.*

437. Stainless Steel
Two booklets on 200 series of low nickel, austenitic stainless steels, give applications and properties compared with 300 series. *Republic Steel*

438. Stainless Steel
32-page catalog gives chemical composition, strength factors, physical properties and applications of 200, 300, 400 series stainless. *Sharon Steel*

439. Stainless Strip
32-page brochure on 20 types of stainless strip steel. Recommended applications, chemical, physical and mechanical properties, corrosion resistance. *Superior Steel*

440. Stainless Steel
16-page booklet on Type 430 stainless gives physical properties and analysis, corrosion resistance, fabrication, application and care. *Washington Steel*

441. Stainless Steels
10-page booklet contains charts, graphs, data on cold rolled mechanical properties, elevated temperature properties, physical properties and corrosion resistance of chromium-nickel-manganese steels. *Allegheny Ludlum*

442. Steel
14-page manual on sizes and types of electric furnace steel. List of products equipped to roll. *A. M. Byers*

443. Steel Bars
24-page engineering booklet gives description and eight case studies of fatigue-proof bars. *La Salle Steel*

444. Steel Castings
32-page bulletin tells how castings are made, how they are designed and specifications for steel castings—heat treatment, chemistry, properties. *Keokuk Steel Casting Co.*

445. Steel 52100
Stock list on 52100 tubing, bars and ring forgings. *Peterson Steels*

446. Temperature Control
Selection of thermal elements for use in 400 corrosive materials. Recommended material, protective well and socket material. *Partlow Corp.*

447. Testing
Literature on pickle pills for testing strength of pickling solutions. *Ferro Corp.*

448. Testing Machines
Revised Bulletin 47 on Super "L" hydraulic universal testing machines. Loading systems, indicating systems, capacities. *Tinius Olsen*

449. Testing Machines
8-page guide to Riehle testing machines and instruments. *Riehle*

450. Thermocouple Insulators
New Bulletin No. 300-56 on complete line of thermocouple insulators. Dimensions, sizes, types of insulators. *Claud S. Gordon*

451. Thermocouples
32-page file book on pyrometer accessories, Selection of thermocouple and protective tube. *West Instrument Corp.*

452. Thickness Tester
Data sheets give ranges, principle of operation of nondestructive thickness tester. *Unit Process Assemblies*

453. Titanium Alloy
Data sheet on MST-6Al-4V high temperature titanium alloy. Creep and fatigue properties. *Mallory-Sharon Titanium Corp.*

454. Titanium Powders
Data on high purity and commercial titanium powders. *Hawkridge Metals*

455. Titanium Wire
Conversion table for titanium wire and rod converts diameter sizes to feet per pound or pounds per foot. *Johnston & Funk Titanium*

456. Tool Bits
Folder contains information on finish and shapes available with sizes in which they can be obtained. *Vanadium-Alloys*

457. Tool and Die Steels
26-page book on six oil and air hardening steels for high-production tools and dies. Many uses illustrated. *Bethlehem*

458. Tool Steel
4-page bulletin on Ry-alloy, oil-hardening tool steel. Applications, advantages, heat treatment and forging practice. *J. T. Ryerson & Son*

459. Tool Steel
Chart gives stock sizes, analyses and properties of A2 and O1 precision ground tool steel. *Uddeholm*

460. Tool Steel
Wall chart showing more than 300 varieties of tool steel with trade name of manufacturers. *Vulcan Crucible Steel*

461. Tubing
New book on production of seamless and welded tubing. Forging and fabricating operations. *Ohio Seamless Tube*

462. Tubing
64-page handbook on use of tube mills in manufacture of pipe and tube. Step-by-step description of the electric-weld process. *Yoder Co.*

463. Ultrasonic Inspection
Ultrasonic Inspection Newsletter, No. 2, contains article on immersion inspection of wing spars for jet fighters. *Sperry Products*

464. Vacuum Melting
8-page bulletin on production and testing equipment for vacuum melting. Alvantage. *Utica Metals Div., Kelsey-Hayes*

465. Vacuum Metallurgy
Information memo describes the high-vacuum technique and pumping systems. *Consolidated Electrodynamics, Rochester*

466. Weight Tables
New 12-page booklet gives instructions for determining weights of square and rectangular steel tubing. *Revere Copper and Brass*

467. Welding
Data on welding positioners from 500 to 100,000 lb. capacity. *Harnischfeger*

468. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

469. Welding Stainless
New 12-page booklet—a guide to better welding of stainless steels. In question and answer form. *Arcos Corp.*

470. X-Ray Equipment
4-page folder on X-ray viewer. Advantages and applications. *Philco*

471. X-Ray Films
6-page folder on industrial X-ray films and processing chemicals. Exposure characteristics. Selection of best film for each job. *Ansco*

472. X-Ray Microscope
New catalog includes micrographs, theory of operation and technical details. *General Electric, X-Ray Dept.*

473. Zirconium
Vol. 1, No. 1, More Zr Facts, describes zirconium production processes. *Carborundum Metals Co.*

February, 1958

241	261	281	301	321	341	361	381	401	421	441	461
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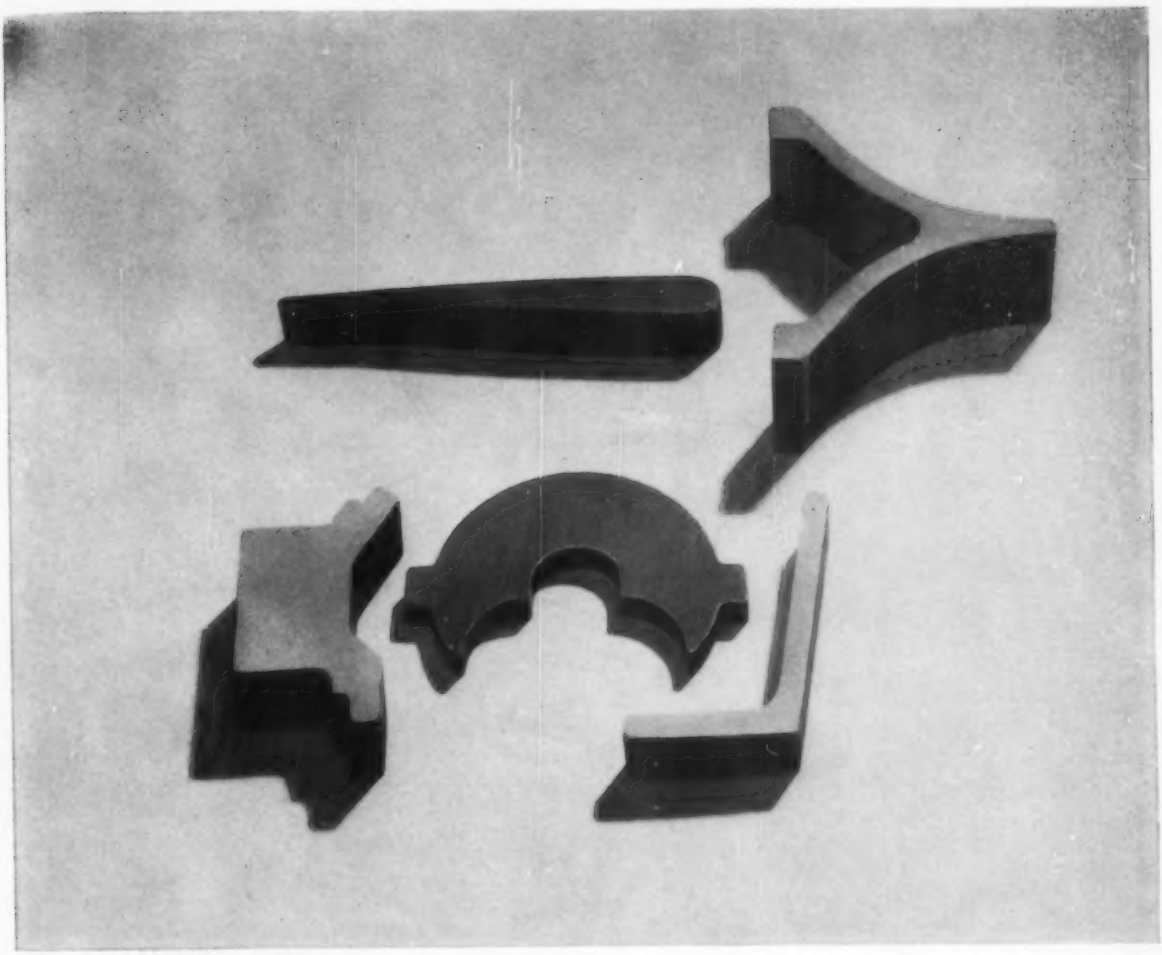

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The tube sheets are for large diameter exchangers. Brass plate, ⅜" thick, is brazed to 3¾" thick steel plate with .005 x 6" Silvaloy 45 and APW Black Flux. Furnace heating was used.

Silvaloy Brazing Alloys and APW Fluxes are helping to speed production, lower costs and improve brazing results in many fields. Call your nearest Silvaloy Distributor for information or technical assistance. ★ ★

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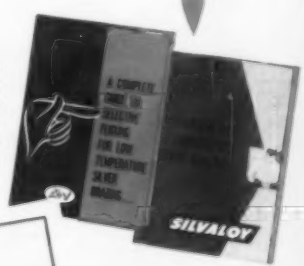
Two complete reference manuals for low temperature silver brazing and fluxing are available upon request. Send for either one or both. ★ ★ ★ ★



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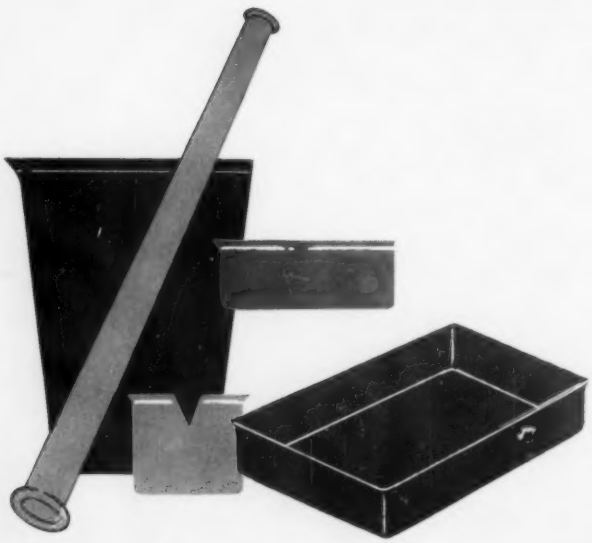

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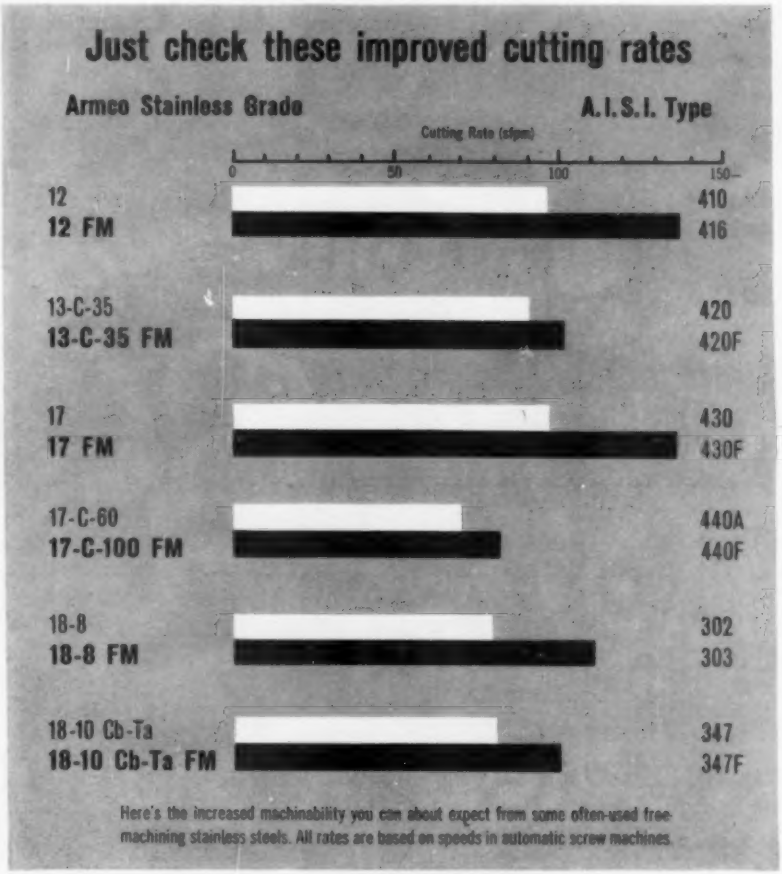
Why production steps up with ARMCO FREE-MACHINING Stainless Steels



Here's the increased machinability you can about expect from some often-used free-machining stainless steels. All rates are based on speeds in automatic screw machines.

In service, the toughness of stainless steels gives them endurance that ordinary metals can't match. But in part-production, this very toughness can limit machining speeds. That's why Armco produces free-machining counterparts for many widely-used grades of stainless steel bar and wire. Small additions of certain elements make these special grades machine faster. Production rates jump.

TRY THEM

Here's how to prove it for yourself. If you now machine parts from a standard stainless steel, just contact your nearest Armco Sales Office or Armco Stainless Distributor. They will be glad to arrange for you to try out the Armco Free-Machining counterpart of the grade you are now using.

Or, if you would like more information about uniform-quality Armco Stainless Steel bar and wire, just fill in and mail the coupon.

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In addition to stainless steel sheet, strip, plate, bar and wire, Armco produces these other steels for top-quality products: ALUMINIZED STEEL, ZINCGRIP®, ZINCGRIP PAINTGRIP®, Cold-Rolled PAINTGRIP, Enameling Iron, Electrical Steels, High Strength Steels, Welded Steel Tubing, and Long Ternes, as well as high-quality hot- and cold-rolled sheets.

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SPECIAL NEWS TO NUCLEAR REACTOR DESIGNERS AND BUILDERS:

Reactor grade zirconium sponge is available for delivery *now* at the lowest price in zirconium history—$7.50 lb. for 1,000 lb. lots F.O.B. from the industry's pioneer producer—THE CARBORUNDUM METALS COMPANY.

Increased efficiency in zirconium production at Carborundum Metals provides new customer savings. Volume is up at two completely integrated plants to the point where zirconium can be sold at the lowest published price ever offered by any manufacturer, anywhere—in these quantities for immediate delivery of the same high quality metal. To reactor designers and builders, this news is of special significance—zirconium can now be specified with definite assurances of a lower price, uniform high quality and dependable delivery. The outstanding nuclear, corrosion and strength properties of zirconium are available to add to the efficient performance of every reactor. Reactor builders are urged to submit orders early for production scheduling.

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- Prices on zirconium INGOTS, both reactor and commercial grade, are also available based on the new lower sponge prices.

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RESULT: Increased production, less operator fatigue, metal flows more readily, pools more evenly to produce cleaner, stronger welds — because all welding is done in the natural *downhand* position.

For more information about how these useful machines can save you money, write to Department 310E, Harnischfeger Corp., Milwaukee 46, Wis.

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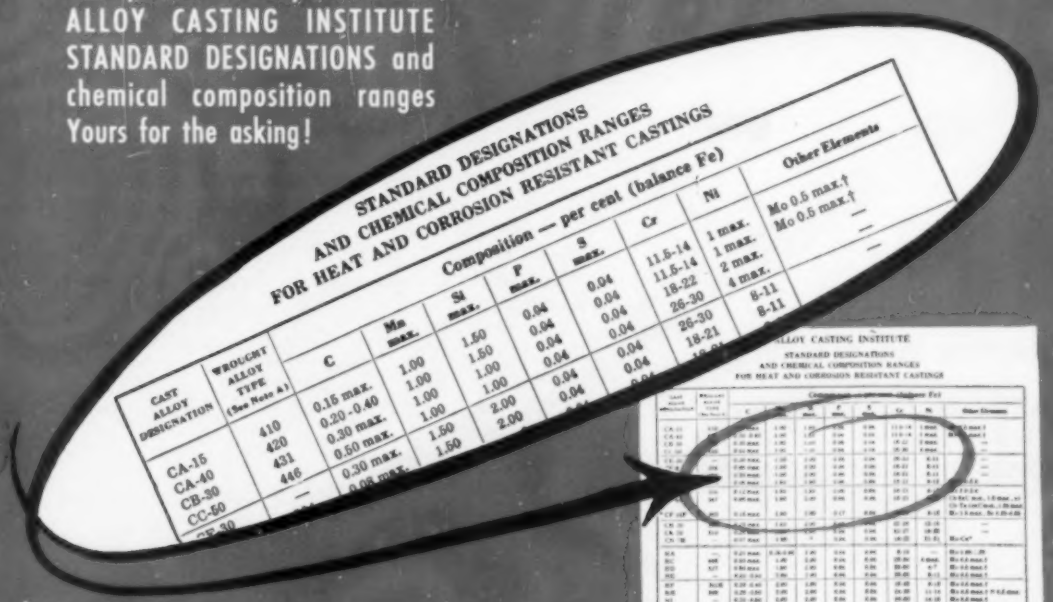

STANDARD DESIGNATIONS
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CAST ALLOY DESIGNATION	WROUGHT ALLOY TYPE (See Note A)	Composition — per cent (balance Fe)						
		C	Mn max.	Si max.	P max.	S max.	Cr	Ni	Other Elements
CA-15	410	0.15 max.	1.00	1.50	0.04	0.04	11.5-14	1 max.	Mo 0.5 max.†
CA-40	420	0.20-0.40	1.00	1.50	0.04	0.04	11.5-14	1 max.	Mo 0.5 max.†
CB-30	431	0.30 max.	1.00	1.00	0.04	0.04	18-22	2 max.	—
CC-50	446	0.50 max.	1.00	1.00	0.04	0.04	26-30	4 max.	—
CE-30	—	0.30 max.	1.50	2.00	0.04	0.04	26-30	8-11	—
		0.05 max.	1.50	2.00	0.04	0.04	18-21	8-11	—

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...also cut costs by 25%

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One of the vital components of the plant is the anode jack assembly. The assembly operates under a 60-ton load and under adverse conditions. Failures here cannot be tolerated because they would stop production and create a tough maintenance problem.

The chief project engineer knew he could not take chances . . . and set up tests simulating as nearly as possible actual operating conditions. Sample parts were made from those grades of steel bars which appeared to be most suitable.

In comparative accelerated tests, considered the equivalent of 8 years' service, STRESSPROOF and FATIGUE-PROOF were selected not only for the necessary properties but because they performed best under these rigid tests.

Vendors making the parts also found that these steel bars consistently machined easier than the heat treated steels and cut their costs.

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TEST No. 1: After submitting sample shafts of each of the analyses shown at the left to the accelerated tests for wear, strength, and overload, STRESSPROOF anode shafts were proved superior. (1) STRESSPROOF gave consistent and faster machining. (2) STRESSPROOF shafts required no straightening. Other materials warped after machining. (3) STRESSPROOF showed excellent wear characteristics under applied load. (4) STRESSPROOF shafts were produced at a savings of 25% over the other materials tested.

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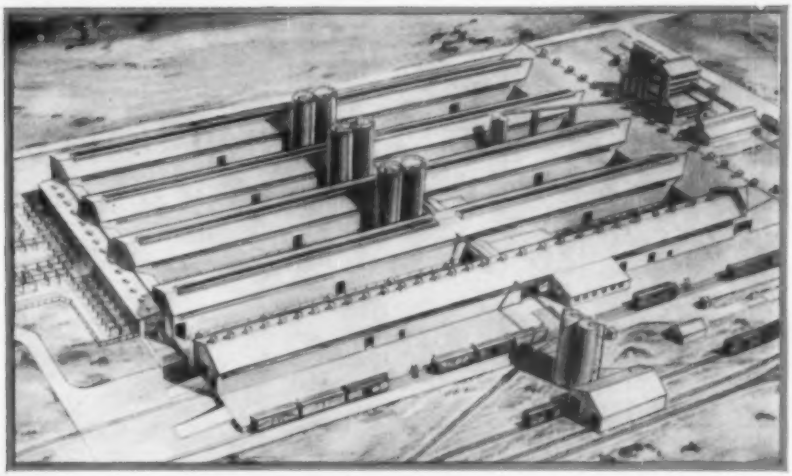
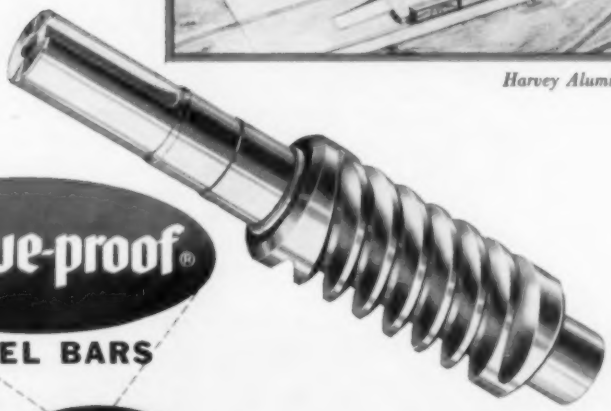
hardnesses



Harvey Aluminum Reduction Plant, The Dalles, Oregon.



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TEST No. 2: Sample bars of each of the analyses listed at the left were also put through a test equivalent to 8 years' operation. After completion of tests, FATIGUE-PROOF steel showed excellent ability to work-harden and to withstand operating loads. Machinability was superior to the other grades tested and total cost of producing the worm gear was reduced by 25% with the use of FATIGUE-PROOF steel.

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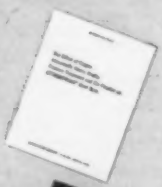

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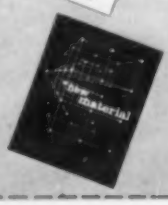

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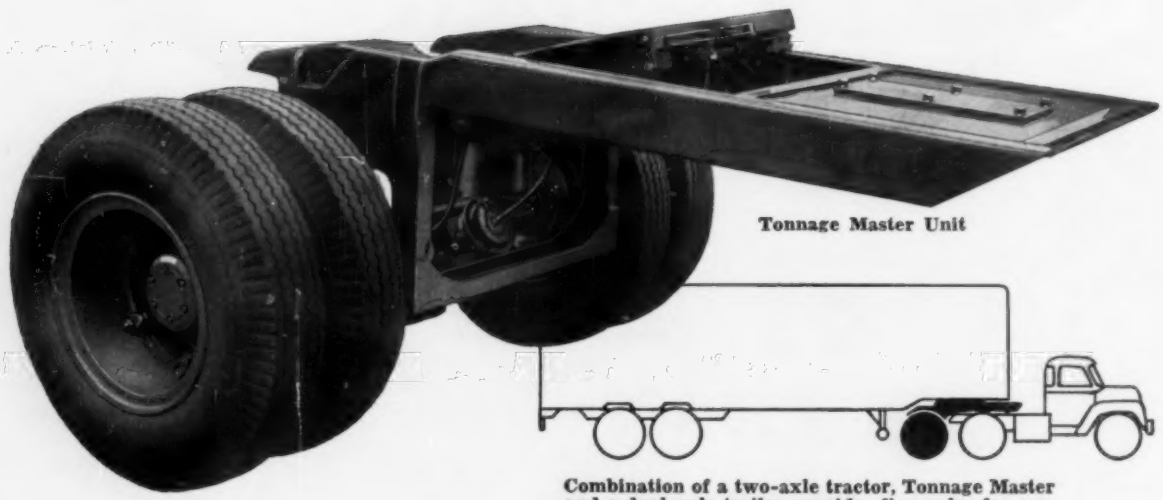

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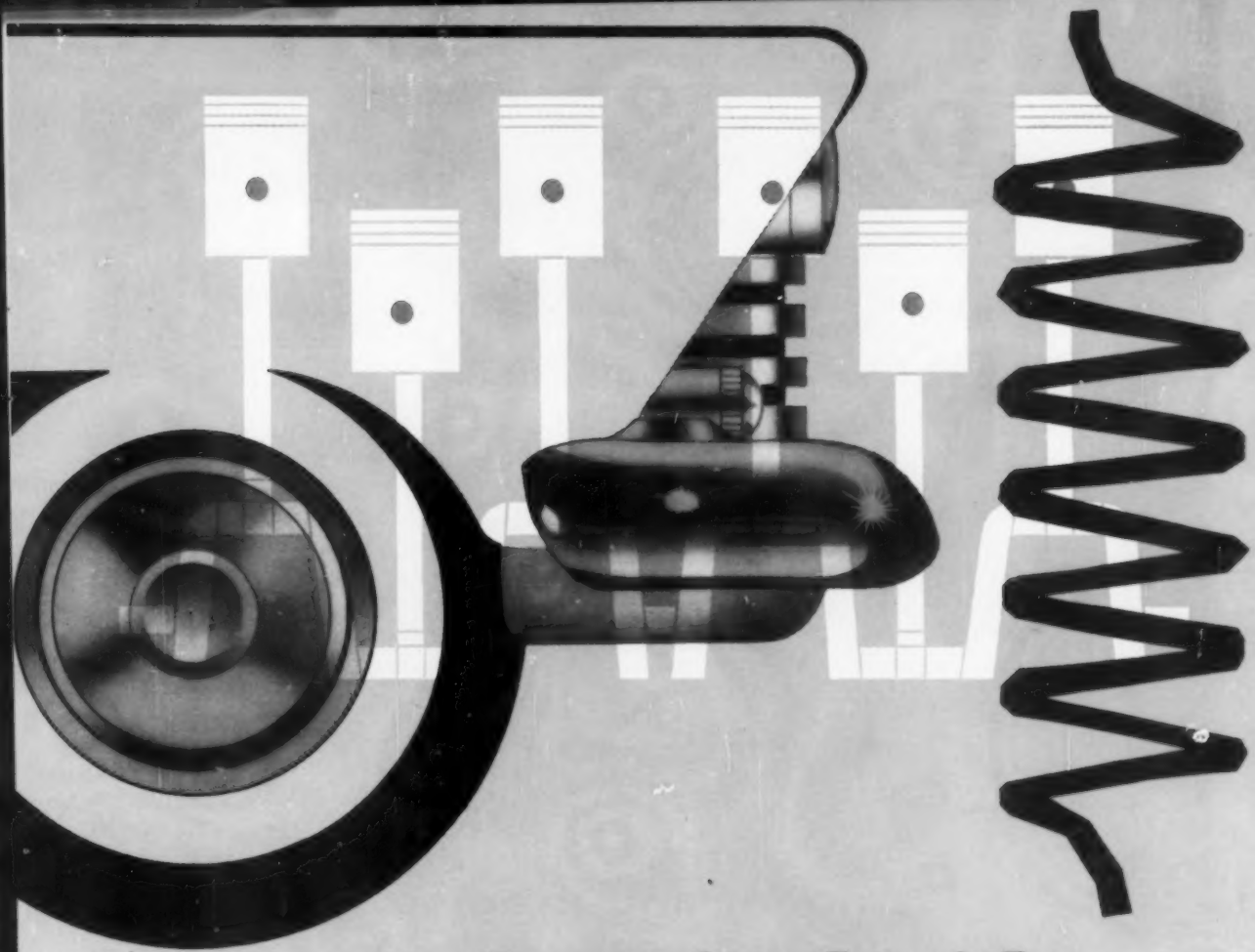

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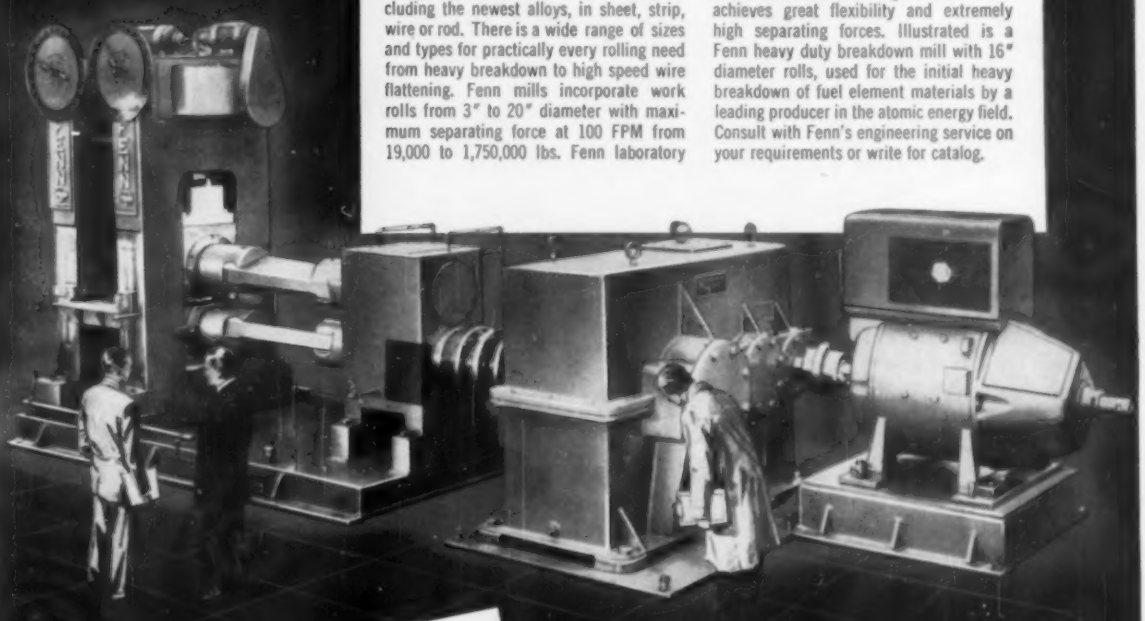

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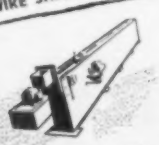

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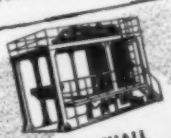

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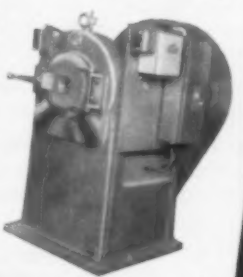

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A Thought on Sputnik

CAUGHT A GLIMPSE of the shiny encasement of the poor dog hurrying along the murky Cleveland horizon and thought how much more important it would be to see the arm which threw him so high, and then found myself repeating the eighth Psalm as I did so often on those nights in my youth spent on the high Western prairies, cloudless for a week on end:

Oh Lord our Lord, how excellent is Thy name in all the earth! Who has set Thy glory above the heavens . . .

When I consider Thy heavens, the work of Thy fingers, the moon and the stars, which Thou hast ordained;

What is man, that Thou art mindful of him? and the son of man, that Thou visitest him?

For Thou hast made him a little lower than the angels, and hast crowned him with glory and honor . . .

O Lord our Lord, how excellent is Thy name in all the earth!

Lots of Oxygen at J. & L.

Along 5½ miles of the Ohio River below Pittsburgh stretches the Aliquippa works of the Jones & Laughlin Steel Corp. A scant 180 ft. of this includes a new building containing two steel furnaces which are expected to provide a third of the steel made in the whole plant. These vessels are the first basic oxygen converters in operation by a major integrated steel producer in America.

Metal Progress has devoted considerable attention to the "L-D" process, developed by the Austrians early in this decade. Producing steel of openhearth quality at bessemer speed and cost, the method achieved immediate popularity. Engineers visited the plants at Linz and Donawitz to appraise the process, and installations sprouted in many countries, including one at Hamilton, Ont., and another in Detroit. The Jones & Laughlin staff in Aliquippa, who are expected to convert the iron from five blast furnaces into steel (and do this with five openhearths and three bessemer converters, duplexing for maximum steel production), found the method admirably suited to such an operation. Kaiser Engineers designed the converters and auxiliary equipment, and Air Products Inc. the oxygen plant.

Taking a lesson from the Vanguard fiasco, J. & L. made sure that the equipment worked properly before inviting outsiders to come and look. After about two weeks of learning which buttons to press, 150 heats had been made and the operators had become fairly conversant with their duties. Production began officially on Dec. 10, 1957, and several members of the Fourth Estate – including the writer who negotiated safely the Pittsburgh traffic – were there to view the results.

The operation is deceptively simple. The two vessels stand side by side; the operating vessel leans forward, and 10 to 15 tons of scrap is dumped into it. This is followed by some 40 tons of hot metal and a small amount of flux. The furnace straightens up, and the water cooled oxygen lance is lowered. After a minute or so of probing to break the slag blanket, there is a sudden roar. Flame and smoke spurt from the mouth to be sucked by huge fans into a hood leading to the dust precipitator. Without this precipitation, incidentally, several tons of very fine iron oxide particles would be donated to the Aliquippa atmosphere every 45 min. since 54 tons of steel is tapped at the end of the 22-min. blow. After tapping, the steel is poured into ingot molds in the usual manner – heat size being adjusted to ingot mold capacity. At present, the process is being used for low-carbon rimmed and capped grades, though in the future it is planned to produce medium-carbon killed and semi-killed grades as well.

When the oxygen process, as modified by Jones & Laughlin, is compared to the other steelmaking processes, several contrasts are apparent:

1. Charging is simple, since only one furnace is operated at a time. There is thus no delay resulting from the interference of other charging cars waiting to charge other furnaces with either scrap or hot metal. Charging takes no more than 3 min. under present conditions.

2. Since the process operates on a 25 to 30% scrap charge, the furnaces can be supplied almost entirely by home scrap. This is important when scrap dealers are asking high prices.

3. Because all of the fume is pulled into the dust precipitator, the converter area is extremely clean; this is definitely the reverse of the surroundings of other steelmaking methods.

4. The process is apparently rather insensitive to variations in chemical analysis of the iron. One point brought out in a conversation with H. B. Emerick concerned one type of ore smelted at Aliquippa. It yields an iron fairly high in titanium – about 0.1%. In steelmaking the titanium oxide produces a very fluid slag, which "slops" out of the mouth of the bessemer converters and splatters the surroundings. No "slopping" occurs in the L-D process; operators regard this as a decided improvement in working conditions.

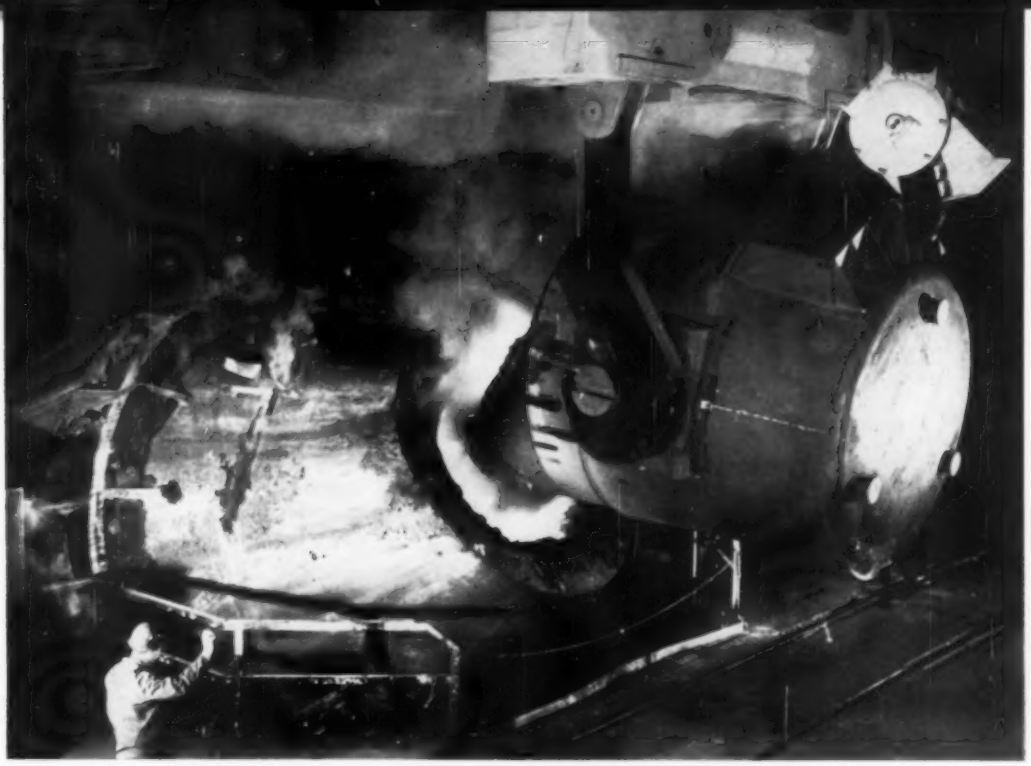
It will be interesting to see what happens in this plant with its bessemers, openhearths and oxygen furnaces when the demand for steel reaches its former high levels. At present, the Jones & Laughlin management plans on making up to 750,000 tons yearly by operating one furnace at a time. Forty heats are produced daily, and a campaign is expected to be 300 to 400 heats before relining is necessary. Thus eight to ten days elapse before relining is necessary, but it then takes from four to five days. This means that a furnace will be in operating condition, but idle, for a few days while the other is reaching the end of its campaign. In times of high demand, an idle furnace is deplored. Since it is common experience that any scheme dreamed up by a steelman to increase production will be attempted, one can predict that Jones & Laughlin will not only try to operate both furnaces continuously (except for relining time, of course) but will also increase the charge to around 90 tons. I'll take any bets right now that those two – later, three – furnaces will be pouring at least 1,000,000 tons of steel a year before 1963.

C.W.

"Climate" for Crash Programs

Nowadays the public prints are full of chatter about too few engineers, too few scientists, "crash programs" and so on, written by people who probably could not appraise the relative importance of the experiment where Otto Hahn and Lise Meitner bombarded uranium with neutrons and got some unexpected radioactivity and, let us say, the wrap-around windshield. What I mean to say is, let us clearly distinguish between discoveries in fundamental science (which have an infinitesimal chance of occurring in a "crash program") and improvements in technology – that is, the *application* of fundamental science to industrial production.

Even these improvements in industry cannot be made without proper climate. A few years ago the Editor spent some time collecting "Milestones in American Metallurgy" in the years since the American Society for Metals was founded, and later found that a minor percentage of them occurred in large plants. Apparently the little fellow is the one who is trying to do things better in order to find something new to sell! This matter of "climate" also applies to Harry McQuaid's story about the "invention" of S.A.E. 4340 steel 25 years ago – a steel which is the favorite of aircraft engineers for tough, high-strength parts, the melter who likes to make it, the mill metallurgist and inspector to work with, and the sales department to sell.



Hot Metal Pours Into a Basic Oxygen Converter at the Aliquippa Works of the Jones & Laughlin Steel Corp.

It appears that a General Motors truck with a new heavy-duty brake was giving trouble on the proving ground. The axle shafts were twisting off at the spline on the gear end. H. W. Alden, Timken-Detroit's chief engineer was on the hot seat, and he gave Harry, his metallurgist, just five minutes to call the steel mill in Canton and give them an analysis which would eliminate this axle failure. To quote his words:

"McMullan and I said to ourselves: 'What can we do to 3240 to improve its impact and transverse properties?' As an ex-melter, my first reaction was to increase the manganese limits from 0.30 to 0.60% to 0.70 to 90%, to aid in blocking and cleaning up the heat, to improve cleanliness, to overcome any adverse effects of even the quite-low sulphur, and to improve the uniformity of the martensite formed on quenching.

"The next change was to drop the chromium from 1 to 1.25% in the old 3240 to 0.70 to 0.90% because I thought it would be good for cold weather impacts.

"Nickel was not changed, with only a momentary debate about increasing it.

"Molybdenum was added because of the good experience I had had with it in the nickel-molybdenum carburizing grades and because I believed in its ability to increase hardenability and decrease the upper critical range on cooling which is helpful in the ingot stage. We thought that if 0.20 to 0.30% molybdenum was good, 0.30 to 0.40% was better.

"The silicon was left at 0.20 to 0.30% because we did not have time to give it any thought. The net result was a specification which we called 4-3240. It was 0.38 to 0.43% C, 0.70 to 0.90% Mn, 0.70 to 0.90% Cr, 1.5 to 2% Ni, 0.30 to 0.40% Mo and 0.20 to 0.30% Si, with grain specified as 'real fine'.

"Not over 15 min. after Col. Alden's request, I had Wilbur Bischoff on the line at Timken's Canton plant. Meanwhile the Colonel had talked with 'H. H.' (Mr. Timken) and 'H. H.' gave orders to rush the steel through at all possible speed. This was a 'crash program'!

"Within two weeks axles of the new steel in test were twisting without breaking. The G.M. boys later admitted that the brakes were much too severe, but they stuck to the new steel."

Perhaps the moral of this story is that things were done so rapidly because men at the very top of the organization were intensely desirous to do something without delay which would remove the stigma from their product supplied to a vitally important customer. It was largely a matter of *climate*, else the best ideas in the world would be postponed until tomorrow, and maybe never carried through. E.E.T.

Vertical Take-Off and Landing

*By LAWRENCE J. HULL**

Thrust from a powerful jet engine gives vertical take-off; control of direction is by slight changes in the direction of the main exhaust, and stability against roll is by jet reaction controls, all electrically interlinked at the pilot's fingertips. (T24, 17-57)

APRIL 11, 1957 marked a milestone in aviation history. On this date a jet airplane designed and built by Ryan Aeronautical Co. made the first complete vertical take-off, transition to horizontal flight, and vertical landing – all in full operational sequence. A photograph of the start of this flight is on the front cover. The plane was the Ryan X-13 Vertijet – a product of ten years of engineering research, design and development.

The conception of the Vertijet goes back to 1947 when the U.S. Navy asked the Ryan Aeronautical Co. to study the feasibility of controlling a jet-propelled aircraft at zero speed. If this could be done, a fighter could take off from any small ship without catapulting (and – equally important – return with safe landing). Carriers could be reserved for attacking or bomb-carrying aircraft. Fighters could land with the Marines without need for long concrete runways. The product which evolved is a delta-winged airplane which unhooks itself from a cable, gracefully curves from vertical to horizontal flight, proceeds on its mission, and returning reverses the procedure and hangs itself from its nose hook on a cable. It is not a flying test platform, it is a research airplane designed to prove the feasibility of jet-powered vertical flight.

Strangely enough, the vertical take-off and landing, or VTOL idea, resulted from the search for a design with higher performance. About 10% of the weight of a conventional plane is required for take-off and landing equipment. When landing gear flaps, doors and drag chutes needed to operate from a long runway are eliminated, the aircraft has higher performance when airborne.

Analysis of the weights of a conventional fighter weighing 20,000 to 30,000 lb. and of a VTOL airplane with an engine giving thrust equal to 125% of the gross weight brings out the following comparison showing that the VTOL has a lighter structure with respect to the weight of the engine:

ITEM	CONVENTIONAL	VTOL
Engine	21%	26%
Structure	28	23.5
Equipment	13	12.5
Fuel	32	32
Military load	6	6
Total	100%	100%

The higher thrust-to-weight ratio of the VTOL aircraft means more rapid rate of climb and higher operating ceiling without decreasing the range. Furthermore, the tactical advantages of such a weapons-carrier are many. Landing fields become a rail on a ship or a cable between two husky trees. A plane that uses air as its runway when climbing straight up can attack an approaching enemy bomber almost before the conventional plane has reached the end of its take-off run! Wing design is not determined by take-off and landing requirements. The aircraft's turning radius would be about one-half that of current fast fighters.

The concept of a craft to meet these requirements started with basic design. Four possibilities are sketched in Fig. 1. In all of them the airplane has engines with net thrust greater than the gross weight, and the lifting reaction goes through the ship's center of gravity. In *A* the tail pipe is rotated; in *B* the whole engine is rotated for various angles of flight. In *C* the necessary lifting force is by two engines inde-

*Chief Metallurgist, Ryan Aeronautical Co., San Diego, Calif.

pendent of the one for forward motion; this design obviously carries a heavy penalty of extra engine weight.

Each of these ideas, with combinations or modifications, has been studied here and abroad, but they all result in a heavier airplane than that sketched in *D*, where the same propulsion system provides the necessary thrust for vertical take-off and conventional flight. There was little or no precedent for our guidance, but some facts were soon apparent: The airframe required an efficient strength-weight ratio to carry an engine having a thrust greater than the gross weight of plane, engine and fuel – in fact an engine with thrust rated at sea level 25 to 30% greater than the gross weight, with the engine itself accounting for one-quarter of the total. Surprisingly, the general configuration that housed this power plant evolved, after long study of models in wind tunnels, into a shape that resembles a modern fighter plane without conventional landing gear, flaps and drag chute.

Zero speed performance and stability (hovering at take-off and during landing maneuvers) for a jet-propelled plane presented a great challenge worthy of the best engineering minds. There is no stream of air passing over wings or fuselage; the aircraft is supported only by the reaction of an invisible stream of hot gas. The control also must be infallible, it must work in a wind – and above all, it had to respond to the touch of the pilot.

The solution was worked out after many years of effort, and depends upon the jet control system. The years 1955 and 1956 were especially busy. Models were flown in free flight tests in one of the wind tunnels at Langley Field by the National Advisory Committee for Aeronautics. The jet engine was simulated by two 5-hp. electric motors turning 14-in. contra-rotating propellers at the forward end of a duct 4 ft. long. The body, wing and tail surfaces, to proper scale, were draped about this air pipe. The model was hung from a slack safety cable (to prevent a crash) through which also were led electrical currents for propellers and for the controls. Three "pilots" to correct for pitch, yaw and roll, respectively, were stationed at strategic points alongside, above and below the wind tunnel; each man moved levers controlling small devices in the model. Pitch and yaw controls for hovering flight were provided by "eyelids" at the rear of the fuselage simulating deflectors for the jet engine's exhaust.

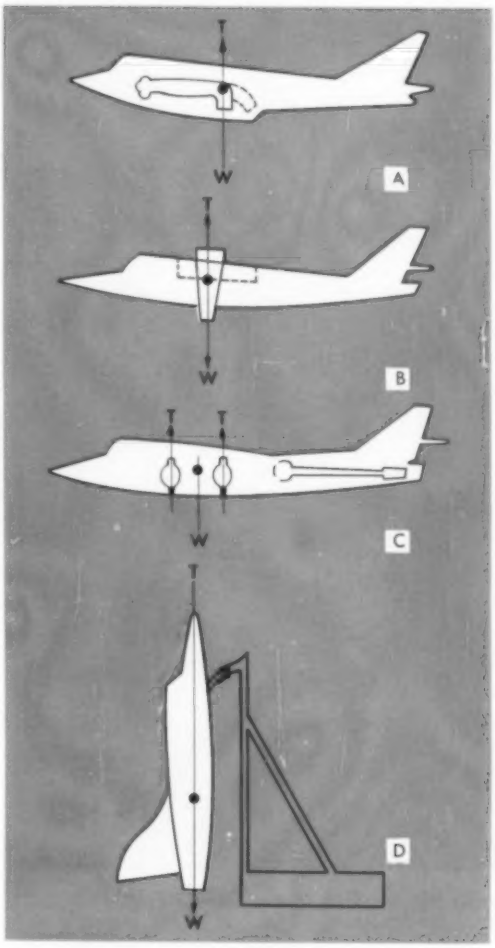


Fig. 1 – Four Possible Arrangements of Engines for Vertical Take-Off Where Thrust Is Vertical Through Center of Gravity of the Airplane

Roll was controlled by deflecting (at will) about 10% of the "exhaust" into small, differentially moving nozzles near the wingtips. Tests included take-off, hovering, transition to forward flight (wherein the air stream in the wind tunnel itself simulated relative motion at various speeds).

By this means a system was devised which uses forces developed by jet engine exhaust deflection to control the Vertijet when no air is flowing over the aerodynamic surfaces.

The X-13 airplane has conventional aerodynamic controls for use in horizontal flight; in transition and hovering the jet stream is diverted appropriately to control pitch and yaw; roll is controlled by diverting air from the

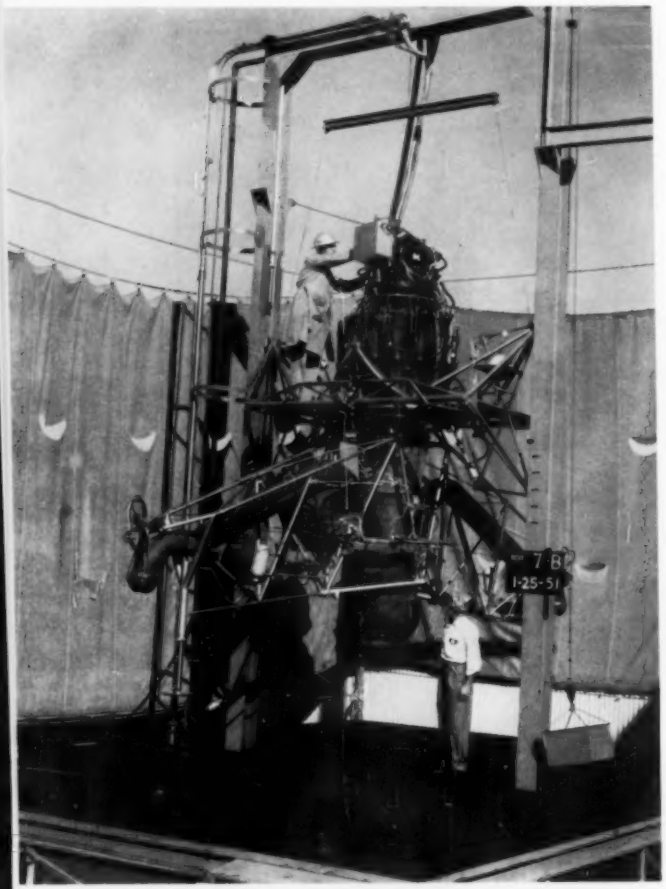


Fig. 2 – One of the Early VTOL Tests for Hovering Flight. A "flying engine", to perfect jet reaction control systems

engine compressor through elbows at the wing tips; "bounce" during hovering, due to lag in response of the turbojet engine to its throttle, is avoided by a servo-mechanism which acts proportionately to the rate at which the pilot changes the position of the throttle. Its nerve system, electronic, proved to be instantly responsive to the pilot's touch. Maneuvering the X-13 almost became a pushbutton operation. Flying skill needed has been compared to that required for operating a helicopter.

The engine is a Rolls Royce Avon, chosen as being the most readily available among those suitable. The power plant section was thoroughly tested. The engine was mounted in a test cell with all necessary attachments and nozzle deflectors, and thrust measured continuously in a 25-hr. run. For 5 hr. the speed was varied from idling to maximum (engine being horizontal). Then followed 15 hr. of similar tests with engine vertical. Finally the first 5-hr. program was repeated.

Tethered flight test vehicles (of which Fig. 2 shows an early version) were built and flown, first to develop the control system, and later to gain vertical flying experience. One of the most valuable items was a flight test simulator which enabled pilots to observe the effects of their control on airplane motion – even to the extent of emerging from "crash landings" with only hurt feelings! A full-size rotatable cockpit mock-up was used to familiarize the pilot with his surroundings. The writer must admit that, after spending a few minutes in this mock-up, he developed a new fondness for the seat and simple controls of a Bausch and Lomb metallograph!

Metallurgical aspects of the Vertijet's design and fabrication were many and varied. These included material selection and fabrication problems in forming and joining. It may not be too widely known that as many as 70 different metals and alloys may be used in production at Ryan at any one time. Of interest is the fact that, although corrosion was not considered a serious problem when designing the X-13, it became one when an X-13 was shipped by boat to Washington, D.C. for a demonstration flight at the Pentagon. The moist salt air of the sea voyage became a much better electrolyte between faying surfaces of dissimilar metals than did the desert air in which the planes made their first flights.

Among the structural materials selected were aluminum alloys 2024 and 7075 for skin and wings, built according to conventional airframe construction. A titanium alloy was chosen for engine shrouds and bulkheads in the tail section. Engine mount fittings were machined from titanium alloy bar stock; 18-8 stainless steel sheet stock was used to fabricate thin-walled ducts. A temporary, but important, landing gear for preliminary horizontal flight tests was constructed of welded S.A.E. 4340 tubing and bar stock, heat treated to a tensile strength of 220,000 psi.

For the most part the designers relied on prior experience for their selection of materials and fabrication processes. In other cases, it was necessary to develop processing know-how and techniques. For example, much of the titanium was fabricated during the early use of this material, and high hydrogen in some of the alloy sheet stopped production because of delayed

cracking on formed parts. The problem was solved when low-hydrogen material was used.

Although a successful welding program was carried out for fusion welded titanium alloy parts, this was given up as impractical because of lack of adaptability to field modification and repair. This remark should not apply to models in production because various aspects of welding have been under continuous study for years at Ryan. This is a matter for a subsequent article on welding of aircraft structures.

Early in the program it was anticipated that some metal-to-metal sliding joints or bearings would operate at temperatures too high for lubricants. The Ryan staff has an extensive backlog of experience with high-temperature exhaust manifolds and joints; galling of metal-to-metal surfaces had been investigated in the laboratory several years ago. Figure 3 shows some of the results obtained on nonlubricated substances at 1300° F., made by interleaving strips of combinations of metals and moving one set with respect to the other under a predetermined unit load on the contact area for a given time and evaluating the results by the surface appearance of the abraded area. Under these conditions, the cobalt-base alloys were outstanding in their resistance to galling. The martensitic Type 410 (12% Cr) behaved unsatisfactorily. The iron-base or nickel-base austenitic alloys showed intermediate galling resistance.

This earlier work is being augmented by further test data. New apparatus shown in Fig. 4 utilizes a tapered pin and a plate with a corresponding tapered hole for test specimens.

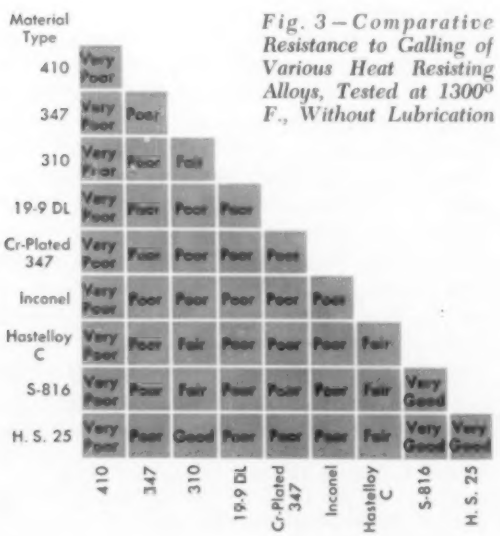


Fig. 3 – Comparative Resistance to Galling of Various Heat Resisting Alloys, Tested at 1300° F., Without Lubrication

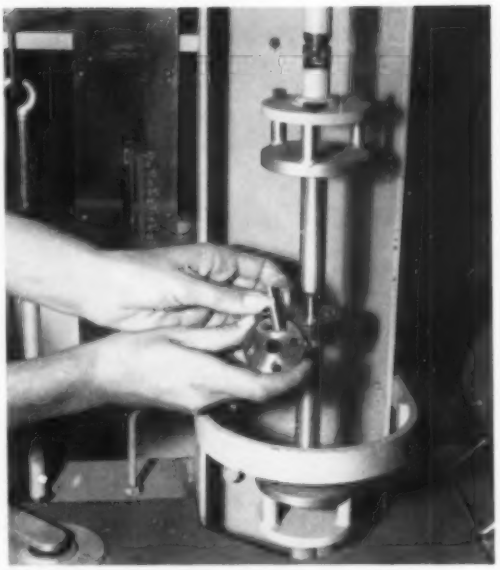


Fig. 4 – Test Machine, Minus Heating Unit, for Testing Galling Resistance of Unlubricated Surfaces. A tapered pin is turned at standard speed in a tapered hole in the test plate under constant loading for standard time. Torque is automatically registered

Temperature, pressure and speed are controlled variables and torque time is recorded. The view is of course minus the tubular heating unit; the hands show samples after test, and the badly galled pin.

The project inspired work to perfect many other processing techniques and stimulated ingenious designs and construction methods. In several places lay-ups of impregnated glass cloth were used for parts with compound curvature where forming of a few metal parts would have been involved and costly.

Since the "freezing" of the materials and design of the Ryan Vertijet, new materials and processes have been perfected which might well be applied to future versions. These were discussed briefly by Bruce Mitchell, chief of structures, before the S.A.E. National Aeronautical Meeting in Los Angeles in October 1957. The precipitation hardening stainless alloys look promising for structural parts. New means for obtaining ultra high strengths in alloy steels would lead to more efficient design. Supersonic versions will make aluminum skins obsolete and will require materials suitable for the higher aerodynamic temperatures created. Undoubtedly, more extensive use will be made of new fusion and resistance welding techniques.

Automation in Heating and Quenching

*by NORBERT K. KOEBEL**

Whether the part in mass production be a knitting needle, a gear or a ship plate, automatic line-ups of heat treating equipment can deliver a steady stream of product of superior uniformity meeting strict specifications for dimension, surface, and strength.
(J general, W 27, 18-74)

IT IS NO NEWS that the major trend in American mass production industry is toward better designs, higher efficiencies and lower costs, and all this is reflected on the metallurgical scene. Parts must be heat treated to highest physical properties, with least variation part to part, automatically if possible. A full discussion of how this is done on parts large or small would be impossible in available limits; this paper therefore will be limited to the more complex operations of heating and quenching, primarily in controlled atmosphere or salt bath.

Very Small Parts

Automatic heating and quenching of very small parts can become equally as difficult as handling very large and bulky parts. If they are put in trays or baskets, the load becomes too dense for uniform hardening of all of them after batch quenching. If the parts are to be case hardened, the handling situation becomes even more difficult, since small, thin parts must have very close tolerance on case depth—0.0005 to 0.001 in. Batch loading means dense charges which prevents free circulation of the carburizing atmosphere, nor will all the parts reach temperature at the same time. Both of these factors lead to nonuniformity.

Therefore, the logical approach—whether the steel be of high carbon or low carbon—is to convey the parts through the heat treatment cycle in a thin layer, first, so all of them reach a uniform temperature simultaneously, second, so

*Director of Research and Manager, Heat Treating Furnace Div., Lindberg Engineering Co., Chicago. This paper was prepared at the request of the Industrial Heating Equipment Assoc. and presented at the I.H.E.A. meeting during the National Metal Congress in Chicago.

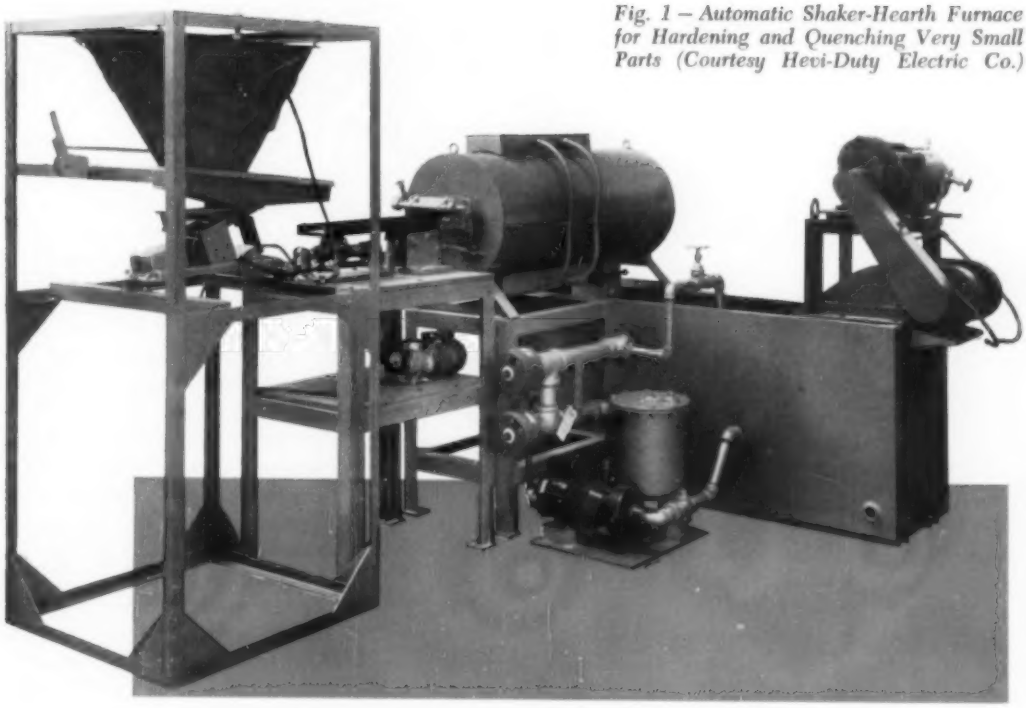


Fig. 1 – Automatic Shaker-Hearth Furnace for Hardening and Quenching Very Small Parts (Courtesy Hevi-Duty Electric Co.)

all are in intimate contact with the furnace atmosphere, and third, so each individual part can be properly quenched.

A shaker hearth (also called reciprocating hearth, snap hearth, and vibrating hearth) is best suited to carry very small parts through a furnace. Alloy conveyer belt furnaces have never proven satisfactory because the small parts invariably get caught in the mesh or links of the belt, which opens up and stretches at heat treating temperatures. (Belts can be woven tight enough for cold operation, as in quench tanks.) Pushing loaded trays through the furnace is out of the question (even if the uneven heating problem can be solved) because more heat is required to heat the tray than the light, shallow load. Fortunately, shaker-hearth furnaces, completely automatic from weighing and loading hoppers to conveyerized quench systems, are available in sizes to handle a few pounds up to a half ton or more per hour. Figure 1 shows such a one. Naturally, the furnace should be proportioned to the part and required capacity; one designed to handle 500 lb. per hr. of screw products would not do too well on 20 lb. per hr. of knitting needles.

Figure 2 shows how the shaker-hearth furnace fits into straight-line production. Note how the quench may be either water or oil by putting two tanks side by side on a movable base; all that is required is to retract the quench chute and move the car one way or the other. This is a handy feature where some items, such as screws, require a water quench if made of straight carbon steel or a lean alloy and an oil quench on the higher alloy steels.

As to heat source, shaker-hearth furnaces are available in electric, full-muffle gas-fired, or radiant-tube gas-fired.

Austempering processes can often be used to great advantage on small parts where unusual physical properties are desired and production requirements and quality control call for complete automation from forming press to final cleaning. An example is a spring clip for an electrical fuse. Here the automobile manufacturer specified that the clip must have spring properties to hold the fuse while some prongs at the base must be bent 180° and staked to the electrical connection. Selective hardening by induction heating imposed problems of handling the various sizes—particularly the coupling of the odd shape to the induction coil. Tests on austempered clips showed unusual toughness coupled with high hardness. Consequently the furnace shown in Fig. 3 was designed. It has a

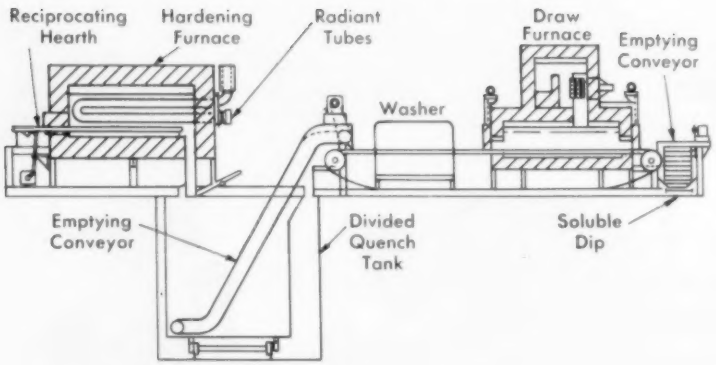


Fig. 2 – Typical Continuous Straight-Line Heat Treating Installation Using Shaker Hearth With Dual Quench, Washer, and Tempering Furnace (Courtesy Holcroft and Co.)

protective atmosphere, a shaker hearth and conveyerized austempering bath (hot salt quench). The parts are delivered from the forming presses by conveyer to the feeding hopper on the shaker hearth, through the heating furnace under protective atmosphere to prevent scaling or decarburization, into the hot salt for quench and tempering, then by belt conveyer through the hot salt, out into a water wash tank (not shown) and finally to the plating machines.

This same idea is also being applied on other types of spring stampings, shoe shanks, sawteeth for chain saws, small tools, structural wall fasteners, and similar products requiring unusual toughness with high hardness. Since tempering takes place in the hot quench bath, the method is ideally suited for automation, but is limited to sections not exceeding ½ in.

Medium-Sized Parts

Medium-sized parts may be classed as bolts, tools, bearing races, automotive and tractor transmission gears, for example. The automatic batch-type furnace, such as shown in Fig. 4, is quite versatile and one of the most popular for handling diversified loads of medium-sized parts. The furnace is completely automatic once the basket or tray is placed on the common charge and discharge table *A*. A pusher chain *B* hugging the side of the furnace and its upstanding dog *C* then pushes the load into the empty vestibule *D*, the front door *E* having of course been raised momentarily. After the vestibule is purged the furnace floor is raised by cylinder *F* and another pusher chain and dog within the furnace casing moves the load into the heating chamber *G*, and the furnace door is lowered. After proper heating and soaking the operations are reversed and the tray-load finds itself on the conveyer in the vestibule, when it is immediately lowered by the elevator cylinder *H* into the quench tank *K*, beneath. Oil circulation system is indicated at *L*. After the work is cooled, the elevator hoists the tray back up to discharge table level, the pusher chain drags it out in the open and the operator transfers it to the washing machine *M*. The automatic cycling of the furnace by program control eliminates the human error in heating and quenching and also eliminates drudgery. One operator can easily handle all the work processed through several batch-type furnaces, including the washing and tempering operations. All that he needs to do is to load the work in the baskets, trays or fixtures in accordance with the pattern set by the metallurgical supervision for each type of part. Some can be randomly loaded into baskets while others must be carefully stacked or placed on fixtures.

Quench tanks should be equipped with powerful recirculating agitators and a cooling system to quench out extremely dense loads. The quench units may also have gas-fired immersion tubes or electric coils for hot oil quench and martempering. The quench tank enclosed and protected is ideal not only for scale-free hardening but also to keep the hot martempering oil from oxidizing. Transfers of the loaded trays from one unit to another can be by overhead monorail or a transfer dolly running in front of the units on a cross conveyer. Furnaces of this type are available heated either by gas, radiant tubes, or electric resistors and are suitably designed for carbo-nitriding, carburizing, or neutral hardening. The furnace shown in Fig. 4 is limited to oil hardening steels, but an additional water quench tank can be put in front of the furnace with a roll-over tilting device to quench the parts without quenching the tray or fixture.

Where the production rate is very high and the part is of such shape that it may be tumbled without nicking, complete automation from machining through heat treatment to finished product can be achieved in the rotary drum type of furnaces. Such parts are those that fall into the

Fig. 3 – Completely Automatic Shaker-Hearth Atmosphere Furnace and Molten Salt Austempering Tank for the Heat Treatment of Spring Clips (Courtesy of Lindberg Engineering Co.)
A is charge end of furnace
B is the furnace casing
C is the molten salt quench
D is the quench agitator
E is a variable speed drive for belt in the quench tank
F is discharge to wash tank (not shown)

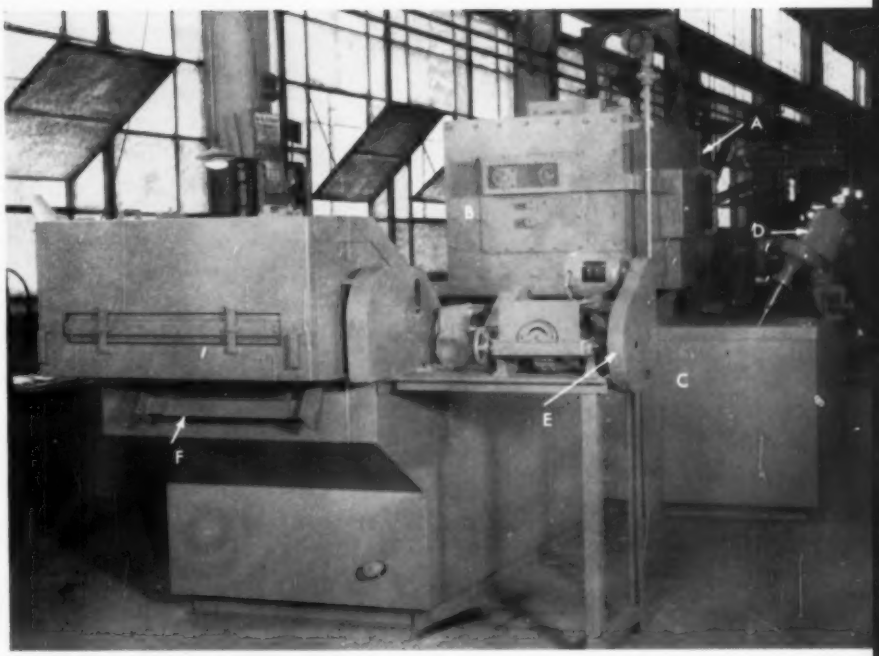
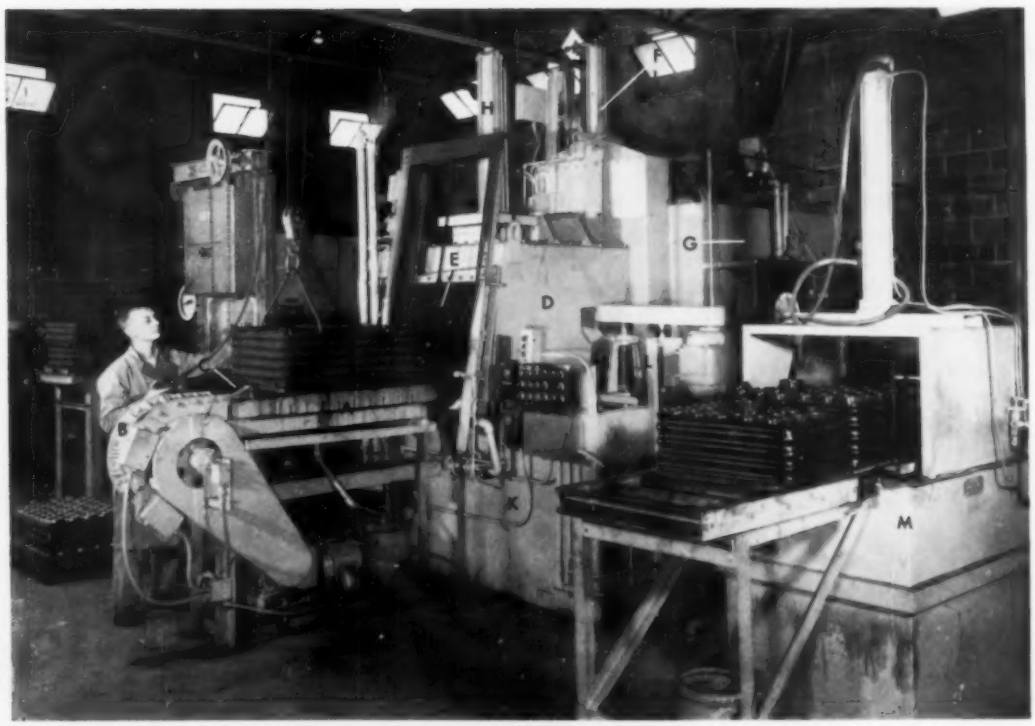


Fig. 4–Batch Hardening Furnace, Automatic From the Time Charge Enters Furnace Until It Emerges. See text for description of labeled portions. (Courtesy Surface Combustion Corp.)



category of balls or rollers for mechanical bearings, grease fittings, and bullet cores. In a line-up of this sort the parts are automatically fed from the rough machining operation to a hopper feeding a washer and thence to a rotary retort for annealing, thence to a second line of machine tools for semifinish machining, to a hopper feeding a second washer, rotary annealing retort and so on to the line of finishing tools, to hopper-loader of rotary retorts for carburizing, thence to a direct quench, rotary retorts for tempering, and finally for cleanup by burnishing or grinding and assembling. Similar lines could contain furnaces with link belt conveyers or roller hearths; the choice depends upon the size and shape of the part and the necessity of eliminating all nicking and mechanical damage.

Automotive and tractor transmission gears are other parts which will not tolerate nicking or distortion. Since gears make up the greater part of the tonnage of heat treated work in the automotive industry, much attention has been given to mechanization. The continuous pusher-type carburizing furnaces heated with gas-fired radiant tubes are used wherever production is heavy. Gears, arriving on hangers carried by overhead conveyer tracks, are placed on a tray with separating fixtures and the load is automatically pushed through a long carburizing furnace. Reaching the far end, the trays may be pushed out a side door and lowered into a martempering quench bath, thence through a washer and a draw furnace, returning to an unloading conveyer alongside the loading platform. This U-shaped floor plan avoids delivery of work far distant from its point of entry.

If the gears must be quenched in a Gleason press or over a plug to control distortion, the operator stands at the rear end of the carburizing furnace and picks the gears off the tray one at a time through a slot in the discharge door. Sometimes only a very small percentage of the production must be press quenched, and these are placed on the top layer, and the remaining load can follow into an automatic mass quenching. Such furnaces may be single, double or triple-track, depending upon production and versatility desired. With a multiple track furnace, the cycle can be varied for each track to adapt the treatment to the needs of the product.

Closer control of the atmosphere's carbon potential, and quenching in hot oil or hot salt (martempering) have eliminated most of the labor of individual press quenching. Not too many years ago, an atmosphere of high carbon potential meant that double heating and quenching was necessary to eliminate surplus carbide and retained austenite; every time a gear is heated and quenched it distorts some more--hence the final press quench. Today this is the exception rather than the rule.

Completely automatic salt baths for heating and quenching are sometimes preferred over atmosphere furnaces. An example of this is in the heat treatment of 106-mm. cartridge cases for recoilless rifles. A train of salt baths is employed for heating, brine quenching, drying, mouth anneal, stress anneal, and wash and rinse. No labor is required other than loading and unloading of the cartridge cases from the conveyor baskets. A salt bath is ideal for mouth anneal.

Large and Bulky Parts

Gantry Furnace — Automation in the heat treatment of large bulky parts, such as landing gear components, "jato" tubes for guided missiles, and large parts in the aircraft industry, is perhaps the most difficult one the furnace designer faces. The prime reason is to assure maximum quality control over the metallurgical properties and minimize distortion. The long, bulky, thin, often unsymmetrical parts must be suspended so as to prevent distortion by their own weight. This poses a uniquely difficult problem in conveyors. Since most such steel components are highly stressed in use, decarburization and scaling must be avoided; aluminum parts must be transferred from furnace to quench in a second or two. Since various alloys must be treated, each in its own temperature-time cycle, the design must be adaptable to oil quench, hot quench for martempering or austempering, and water quench. Washing and tempering should be done from the same fixture.

A furnace with sliding bottom, riding on a gantry above floor level and astride a row of oil, hot salt, and water quench tanks, wash tanks and tempering furnaces in a pit, is one noteworthy to meet the above conditions (Fig. 5). The furnace is electrically heated and atmosphere controlled, designed to heat a net load of 5000 lb. to 1850° F., parts ranging in size up to 12 ft. long and 5 ft. in diameter. The operator hangs the part or parts on an alloy grid at the loading station; all subsequent loading, transfer and quenching operations are done by a pushbutton control far enough away to guard him from any heat or splash.

To charge the furnace, the operator presses the proper button to drive the furnace over the

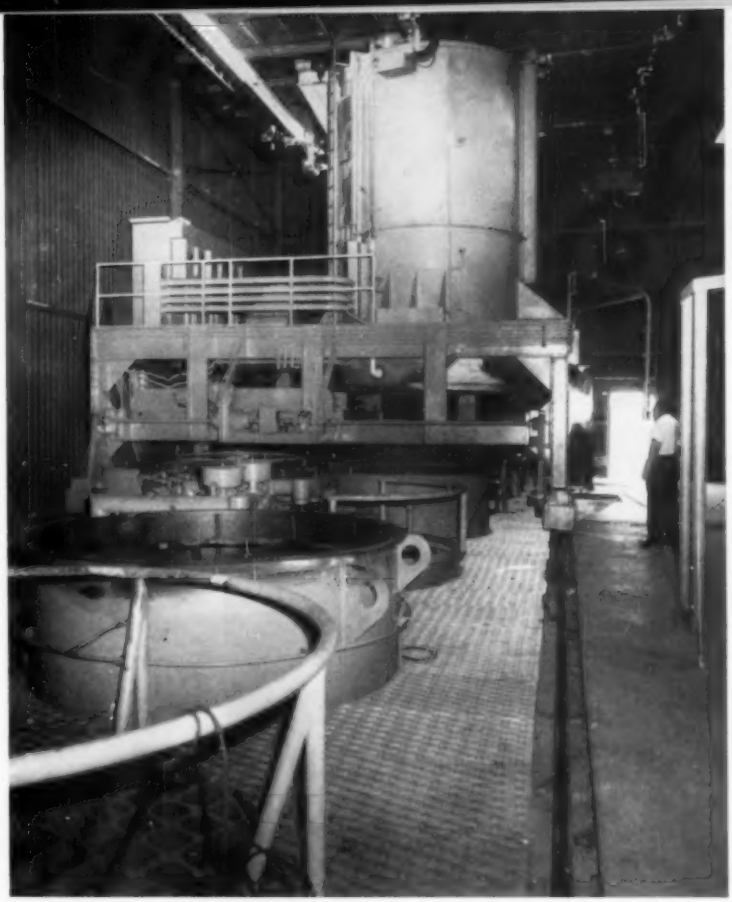


Fig. 5 – Bottom - Quench Gantry Furnace With a Line of Oil, Hot Salt Quench, Wash Tanks, and Tempering Furnaces Below (Courtesy Lindberg Engineering Co.). Starting from the lower left, the pit stations are as follows: loading station, oil quench, hot salt quench, hot water wash, unloading station, tempering furnace No. 1, tempering furnace No. 2. The atmosphere generator and its control instruments are mounted at the end of the pit at floor level. Other accessory equipment such as transformers, contactors, control instruments, are mounted on the gantry

loading station. Another button rolls back the furnace door. A third button drops the alloy hook from the top of the furnace, and the operator secures the hook to the fixture. Pressing another button raises the load into the furnace, closes the bottom, turns on the purging and heating program.

Similarly quenching of the load is done entirely by pushbutton control at safe distance. The alloy lifting hook inside the furnace automatically releases the fixture when the alloy grid reaches a ledge close enough to the bath to submerge the load completely. The hooks of wrought alloy suspending the load are the only parts of the lifting fixture that are quenched; they can take repeated quenching and can be replaced at a low cost.

One tank holding 80,000 lb. of molten nitrate is used for hot quenching, martempering, and austempering of a 5000-lb. load of steel. Two 10-hp. agitators recirculate the salt over the gas-fired immersion heating tubes and through the charge.

The 5000-gal. oil quench tank has two 20-hp. circulation pumps to ensure a uniform quench. It also has a CO_2 fire extinguishing system, heaters, and an adequate cooling system.

In addition to wash and rinse tanks (the latter doubling as a water quench if required) two forced-convection tempering furnaces are provided. They are gas fired and heat by convection – the hot gas is circulated vigorously through the work. Of course the gantry, with its hardening furnace, can be run over the tempering furnaces. The roll-away cover is operated from the pushbutton station, and the load can be dropped from the high annealing temperature into the lower tempering furnace. Note that once a fixture is loaded, it is used through any of these operations in any combination without any manual handling of the parts.

The carbon potential of both the endothermic atmosphere generator and the atmosphere in the furnace is controlled by a dual recording-controller using the dew point method. The operator merely sets the carbon potential required for the steel, and the instrument automatically samples the furnace atmosphere and controls and records it to the desired potential. To assure fast response after loading, the furnace is automatically purged with a stream of prepared atmosphere at 4000 cu.ft. per hr. until the desired condition

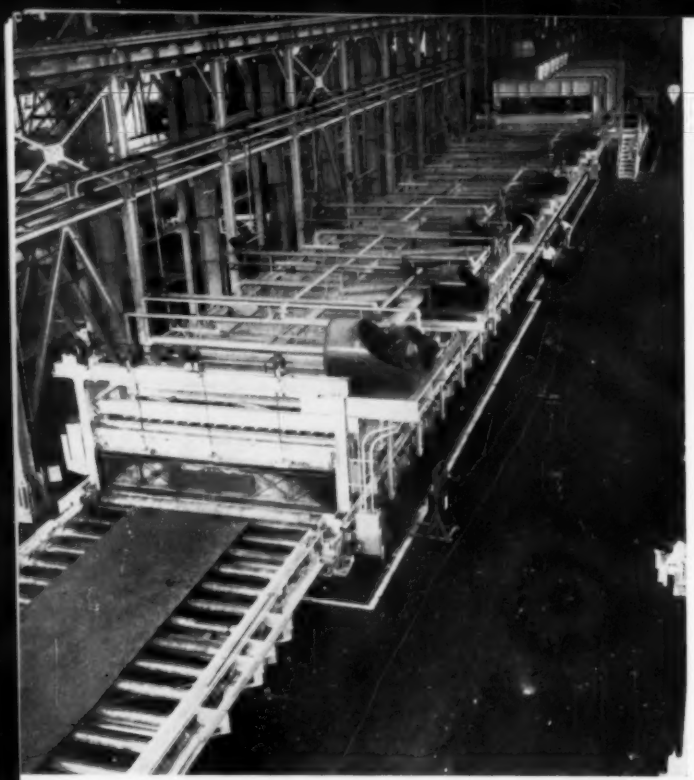


Fig. 6—Continuous Roller-Hearth, Gas-Fired Plate Hardening Furnace With Pressure Quench, Tempering and Transfer Cars (Courtesy Drever Co.)

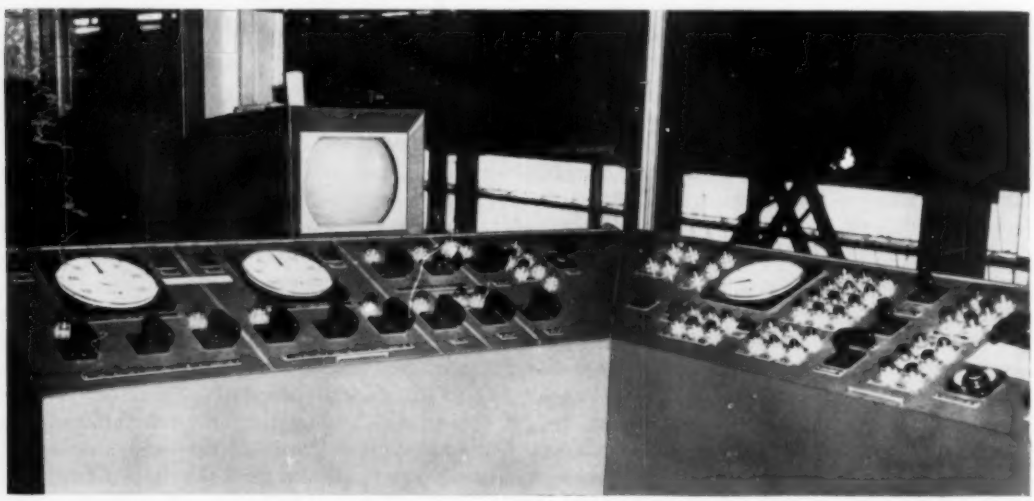
is reached and then the flow is cut back automatically to 1800 cu.ft. per hr. This operation takes about 5 min., long before the load reaches scaling or decarburizing temperature. Transfer from the furnace into the quenching liquid a few feet directly below is so fast that scaling or cooling is prevented. The bottom opening is also ideal to keep the lighter-than-air atmosphere in the furnace and out of the room.

Plate Furnace – Great strides have also been made in the steel industry toward the accurate heat treatment of plate. This is an instance where the shape of the part, although very large, permits a completely automatic heat treating line. Figure 6 shows (starting from the left side) a continuous roller-hearth gas-fired furnace capable of handling plate up to 172 in. wide, 3/16 to 3 in. thick and 40 ft. long (if quenched) and 48 ft. long if normalized and air cooled. The line includes a combination transfer and charging car, next a 145-ft. hardening furnace, a pressure quench, a quench transfer car, a 200-ft. tempering furnace, two conveyer tables, and (at the end of the line) two transfer cars. The quench is high-pressure water in multiple jets striking the plate both from above and below.

All this is operated from a pulpit in the side bay just under the craneway and at the point of greatest activity (Fig. 7). The room contains the control desks, telephone connected to six instruments along the heat treating line, and two closed circuit television receivers connected to six cameras located strategically for the head operator to peer into the heating line at points normally out of sight.

Conclusion – The above examples show that the American furnace industry is in a position to convert heat treating departments to automatic operation, so as to reduce cost and improve quality control whether the plant is one dealing with very small parts, medium-sized parts, or very large and bulky ones.

Fig. 7 – Control Room for Plate Heat Treating Line. Television system enables operator to see all parts of the line (Courtesy Drever Co.)



Heating at High Speed

*By NORMAN H. DAVIES and RICHARD J. REED**

High-speed heating of metal requires both convection and radiation from furnace gases and walls considerably hotter than finishing temperature. Consequently fast controls are necessary to prevent overheating the work if the production line slows down. (F21b, W20h, P11k)

IN PRACTICE no fuel-fired direct heating process is done entirely by convection or entirely by radiation; both occur simultaneously. Frequently used terms such as "convection heating" and "radiation furnace" merely refer to the predominant mode of transfer. In either event the rate of heat transfer is directly proportional to (*a*) the temperature difference between the source of heat and the receiver, (*b*) the area of surface exposed to heat, and (*c*) a heat transfer coefficient, h, which is the sum of h_c due to convection and h_r due to radiation.

A very large amount of work has been done by physicists on the problem of heat transfer from one body to another separated from it and from one part of a body to another part of the same body. This information has been freely used, not alone by designers of heat treating furnaces, but by power plant engineers, manufacturers of chemical equipment, heat exchangers and nuclear reactors – to mention only a few. Consequently the authors' aim is to present in rather elementary terms some of the physical laws governing heat transfer and then to demonstrate how the industrial heating equipment designer and builder attempt to maximize their combined effects to give a high rate of heat transfer.

Some Basic Physics – Figure 1 shows that in convection heating h_c is principally a function of the velocity of the stream of hot fluid scrubbing the surface to be heated, while the mean temperature of receiver and source has some effect on this coefficient.

In radiation heating, h_r depends on (*a*) the emissivities† of the source and the receiver and (*b*) the difference in temperature of the source and the receiver. Figure 2 illustrates an approximate method for determining h_r for various substances, temperatures, and relative sizes.

The principal difficulty in applying the above theory to actual heating processes arises from the fact that the rate of temperature rise of the stock slows down at a pace that depends upon the heat transfer rate, which in turn depends upon the temperature of the stock. This leads to a time-consuming dog-chase-rabbit calculation. In the past, furnace engineers had to predict heating rates by rule of thumb (such as "8 min. per in. of diameter") corrected by their own experience – or else resort to costly models which usually were of limited usefulness. Neither is much help when trying to design something really new – so, as in all fields of engineering, the imaginative approach requires that we return from the empirical to basic scientific methods and data even though they are difficult.

M. H. Mawhinney (Ref. 13) assembled test data from 47 furnaces, including both conventional and high-speed types, to produce the generalized curves of Fig. 3. These curves not only provide the metals industry with one broad comparison of heat transfer rates of industrial furnaces but also show the status of current "high-speed heating" practice.

Of course the term "high-speed heating" is

*President and Application Engineer, respectively, North American Mfg. Co., Cleveland. This paper was prepared at the request of the Industrial Heating Equipment Assoc. and presented at the I.H.E.A. meeting during the National Metal Congress, Chicago.

†A block of graphite and an equal one of firebrick at the same temperature will throw off heat to their cool surroundings (or absorb it from a hotter source) at different rates because they are said to have different emissivities. Emissivity is the relative power of a surface to emit heat by radiation. Emissivity of lampblack is 1.0; of firebrick is 0.52; of polished aluminum 0.06.

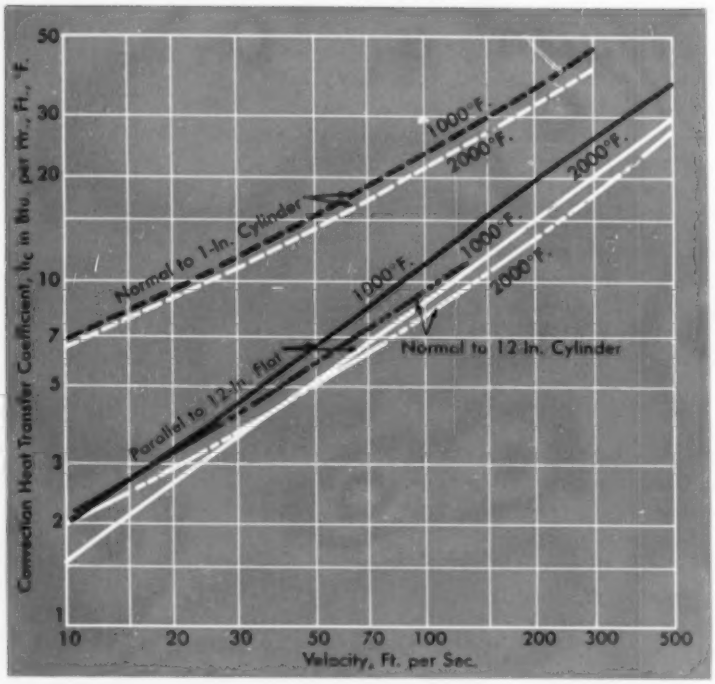
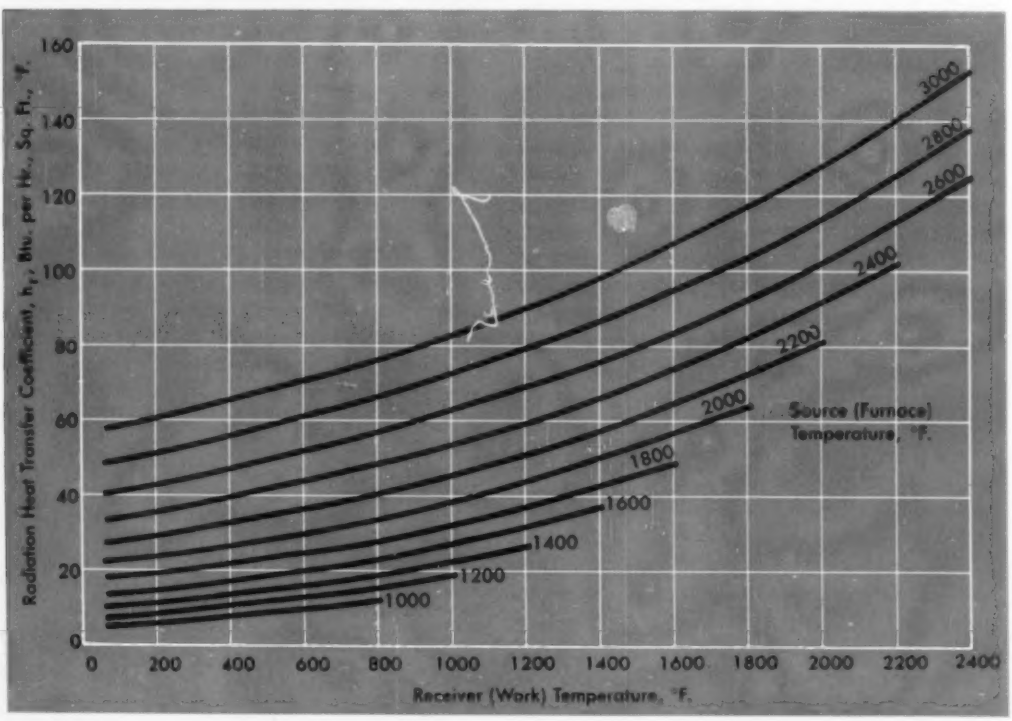


Fig. 1 – Convection Heat Transfer Coefficients for Hot Air Streams

relative, but its current use generally implies two things: First, using a "thermal head" at the end of the heating cycle – that is, a furnace hotter than metal as delivered from the furnace; and second, arrangement of heat source and work so the latter is heated both by radiation and convection on more sides than in conventional furnaces –

Fig. 2 – Radiation Heat Transfer Coefficients From Fireclay or Insulating Firebrick With Emissivity of 0.52. Values of h_r should be multiplied by the factors given in the table below



Receiver	Ratio of Refractory to Metal Area 2	5	10
Aluminum, oxidized	0.22	0.23	0.23
Aluminum, polished	0.057	0.058	0.058
Brass, oxidized	0.68	0.79	0.83
Copper, molten	0.22	0.23	0.23
Copper, oxidized	0.84	1.00	1.07
Copper, polished	0.033	0.033	0.033
Steel, oxidized	0.84	1.0	1.1
Steel, polished	0.68	0.79	0.83

that is, exposing the maximum proportion of the surface to the heat source.

High Thermal Head

Thermal head, or temperature difference between the flame or furnace refractory and the work, is the force driving heat into the work. In conventional furnaces, the wall is maintained at a temperature quite close to that of the desired final work, so the thermal head approaches zero near the end of the cycle. Therefore the metal's temperature rises very slowly as it gets close to the control temperature; this provides a "soaking period" to equalize the core and the surface.

In high-speed furnaces, the refractory walls (and furnace gases) are considerably hotter than the final work; a higher thermal head is maintained right up to the end of the heating cycle, thus reducing the time required for the work to climb the last few degrees. The work is then promptly removed to prevent overshooting, and it is assumed that the core will "soak out" (equalize with the surface) during transfer to the next operation.

Timing of the conveying apparatus is very important to prevent overheating and to allow for adequate soaking. Larger pieces require more soaking time, so it is sometimes necessary to prevent undue surface cooling during transfer – or, in extreme cases, provide a soaking section in the furnace. Professor Trinks' rule of thumb in Ref. 17 gives a dividing line: "For steel stock thicker than 6 in., the stock itself limits furnace capacity; for steel stock thinner than 4 in. the design of the furnace and of the burners limits furnace capacity." High thermal-head heating is therefore limited to small pieces of steel, but pieces of steel of large cross section can still be heated at high speed by the methods now to be described. (Because of their higher conductivity, almost any size piece of copper or aluminum alloy will respond to fast heating methods.)

Arrangements of Heat Source and Work

Exposing all sides of a piece of metal to the heat source yields two gains: First the time to transfer the required amount of heat is reduced, in inverse proportion to the area exposed, and second, the time required for heat to be conducted within the piece to the point farthest from the heat source is reduced. This is termed "conduction time lag" and its magnitude for steel above 1800° F. – according to F. S. Bloom (Ref. 2) – is as follows:

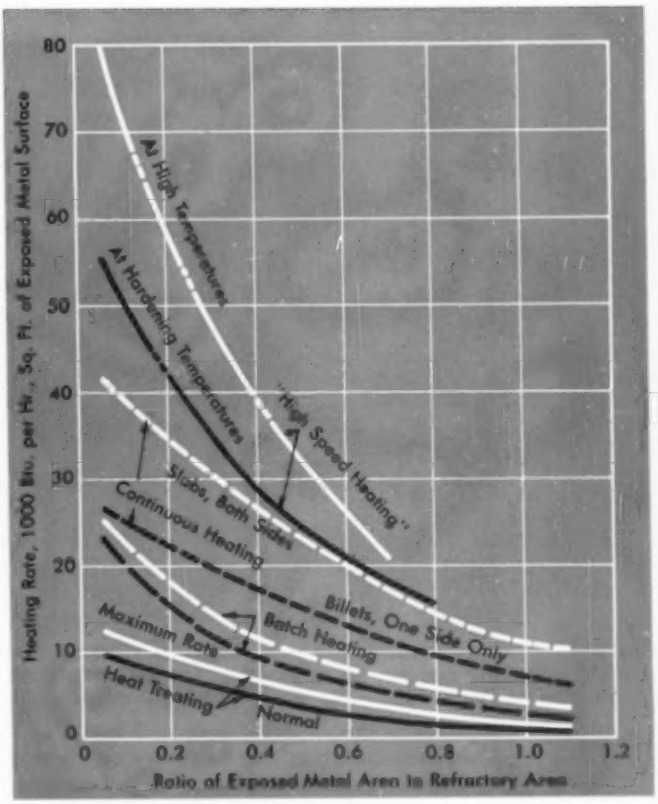


Fig. 3 – Heating Rates in Several Furnace Types as They Vary With Ratio of Area of Metal to Area of Hot Refractory, According to Mawhinney, Ref. 13. Minimum curve for batch heating relates primarily to heating at normal rates for forging or rolling; the maximum curve (in white) also applies to continuous annealing of strip-sheet

Diameter or Thickness	Number of Sides Exposed		
	1	2	4
1 in.	0.80 min.	0.20 min.	0.10 min.
2	3.2	0.80	0.40
3	7.2	1.8	0.90
4	12.8	3.2	1.6
5	20.0	5.0	2.5
6	28.8	7.2	3.6
8	51.2	12.8	6.4
10	80.0	20.0	10.0
12	115	28.8	14.4
16	205	51.2	25.4
20	320	80.0	40.0
32	816	204	102

Recent conveyer designs, and the use of materials capable of withstanding higher temperatures, have permitted the design of continuous furnaces in which *all* sides of *each* piece are exposed to a heat source. This usually involves "wrapping" the furnace around the work, focus-

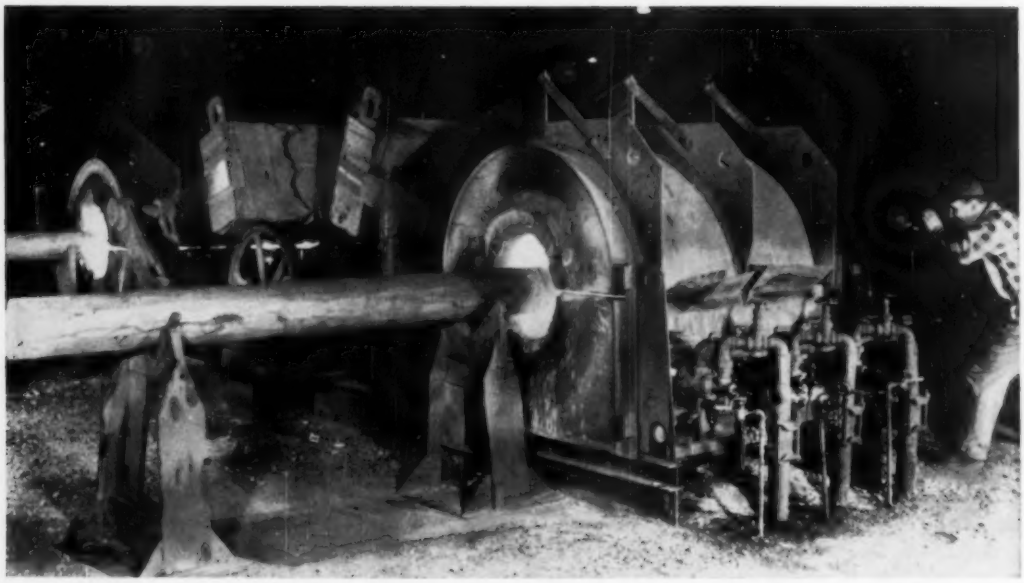


Fig. 4 – Oil-Fired Batch-Type Barrel Furnace for Fast Heating of 8¾-In. Billets. A 5-ft. section is heated for press forging of each throw of a diesel crankshaft. Average heating time for an 8-hr. shift was 36.9 min. The furnace transfers heat to all sides of the billet by convection and radiation

ing radiation on the work or swirling the stream of hot gases around it. Figure 4 illustrates application of this common-sense method to a job that would otherwise have required several cumbersome and expensive box-type furnaces.

Advantages of High-Speed Heating

Less Scale – Oxidation loss is proportional to time at temperature; less heating time results in less scale. In the forging of steel less scale means better die life. Tenacious scale causes further trouble because it may become embedded in the surface and the piece must usually be scrapped. Scale formation also increases with increased velocity if there are oxidizing gases flowing over the metal surface (Ref. 16), so the gain from short time at temperature may be partially offset by the higher velocities in high-speed convection heating.

Smaller Furnaces – Since the time each piece is in the furnace will be less, the hearth area can be less for the same production rate, thus saving floor space. Conversely, greater production is possible with the same floor space. Forging machinery – whether it be a press, shear, upsetter, or a rolling mill – is the most expensive element, and the cost per hour of idle machines will be greater than the hourly cost of idle furnaces. It is therefore economically important to install slightly greater heating capacity than machine capacity. To avoid excessive cooling, scaling, and high labor cost, the furnaces should be close to the machines. High-speed heating equipment is compact and can save money on this score.

Adaptability to Automation – Since timing is so important to high-speed heating, an automatic conveyerized operation goes with it naturally. (Figure 5 gives a good example.) The relatively clean, compact form of most continuous high-speed furnaces adapts them to a production line. Elimination of human error is a further advantage gained by automation.

Disadvantages of High-Speed Heating

Overheating During Delays – When some other part of a production operation is delayed and the work stops moving, the high-speed furnace and work tend to overshoot their intended temperatures; work may be "burned" or excessively scaled; the furnace or conveyer may be damaged. Even the most speedy controls may not be able to prevent overheating if the furnace walls have much heat storage capacity. Provision must therefore be made for quickly emptying the furnace.

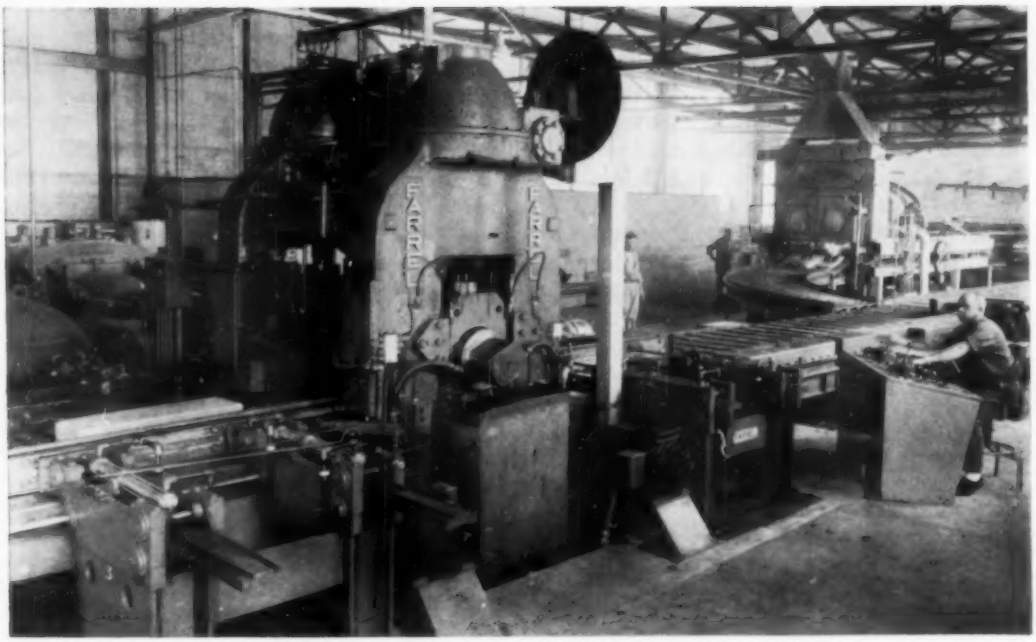


Fig. 5 – Production-Line Operation Using Continuous High-Speed Copper Cake Heater (Right Background) and Reversing Rolling Mill. A pusher mechanism moves the cakes through the elliptical barrel furnace on water-cooled skid rails. Twelve cakes can be heated hourly to rolling temperatures (1500 to 1600° F.)

Nonuniformity – When heat is put into a piece of metal at a high rate, but not evenly over the entire surface, sometimes it does not disperse fast enough by conduction to avoid hot spots, especially on corners directly exposed. Thermal stressing due to uneven expansion may then be a problem – but only with large pieces or alloys having poor diffusivity* such as the stainless steels and high-nickel alloys (see Fig. 6).

Radiated heat and a jet of hot gases both tend to travel in a straight line – thus it is difficult to spread heat uniformly over all the surfaces of most shapes either by radiation or convection. However, it is somewhat easier to predict and control the breadth and effectiveness of a radiated beam than of a convection stream. When the heated area is only a few inches wide, a convection stream is certain to be the easiest method for localized heating. As the size of the piece and the rate of heating increase, however, uniform heating principally by convection usually becomes more difficult than uniform heating principally by radiation.

Many engineers express great concern if any flame impinges on the work. It is the authors' opinion that much of this stems from past experience with hot spots due to localized convection heating. In difficult jobs the furnace designer should consider better methods for delivering heat by convection from the flame and hot gases to the refractory, and thence by radiation to the work. Nonuniform heating of the refractory is not so serious as direct nonuniform convection heating of the work because the heat tends to be "evened out" by conduction within the refractory and in the process of reradiation. By simply arranging the burners so the flame and hot gases scrub the refractory walls, a hotter wall surface (for faster radiant heating) can be maintained with the same fuel input – conversely, less fuel will be required for the same production rate because less heat escapes in the products of combustion.

High First Cost – Although high-speed furnaces are usually smaller and weigh less than conventional furnaces of the same capacity, they often use more expensive refractories, metals, and materials handling equipment. Frequently

*Diffusivity is a measure of the ability of a material to diffuse or disperse heat within itself by conduction. It is equal to the thermal conductivity divided by the density and the specific heat.

tailor-made refractory shapes, water-cooled nozzles, and water-cooled conveyer equipment are necessary. The strictly tailor-made high-speed furnaces have therefore been built primarily for jobs involving large production runs. There are many operations, however, that can benefit from partial application of the same principles in furnaces utilizing standard refractories, burners, and materials handling equipment. For such applications the burner manufacturers are constantly striving to find a general-purpose burner for high-speed heating that can produce a broad expanse of uniformly intense radiating surface or a wide turbulent convective stream.

Convection Versus Radiation

Many estimates, both scientific and unscientific, have been made of the percentage of heat transferred by radiation and by convection with given refractory temperatures and gas velocities, in both conventional and high-speed furnaces. Laboratory attempts have even been made to measure the proportion of heat transfer by radiation and by convection. In most of these studies the *total* heat transfer has been measured, together with enough other factors to calculate either radiation or convection, and the other was then determined by difference. Such tests are invariably limited to specific furnace designs and work shapes; broader interpretations approach sheer guesswork.

Actually, what difference does it make whether heating is done by radiation or convection? Most operations combine the two. It is incorrect to say that convection heating *per se* is superior to radiation heating, or vice-versa. There is no doubt that some jobs could be done more easily by emphasizing convection and others by stressing radiation, but it is impossible to draw a clear dividing line; the emphasis depends on convenience and cost. In other words, the economics of the situation determine the answer.

Conclusion

As long as product quality is good and the production rate high, the mode of heating (radiation or convection or both) does not matter. Costs (labor, furnace, fuel, and power) determine whether a high rate of heat transfer by convection or by radiation is more desirable. If the furnace engineer understands heat transfer phenomena and has access to sufficient cost data, he has the information necessary to forecast the right speed of heating for any job. To this end, the bibliography on p. 198 has been assembled.

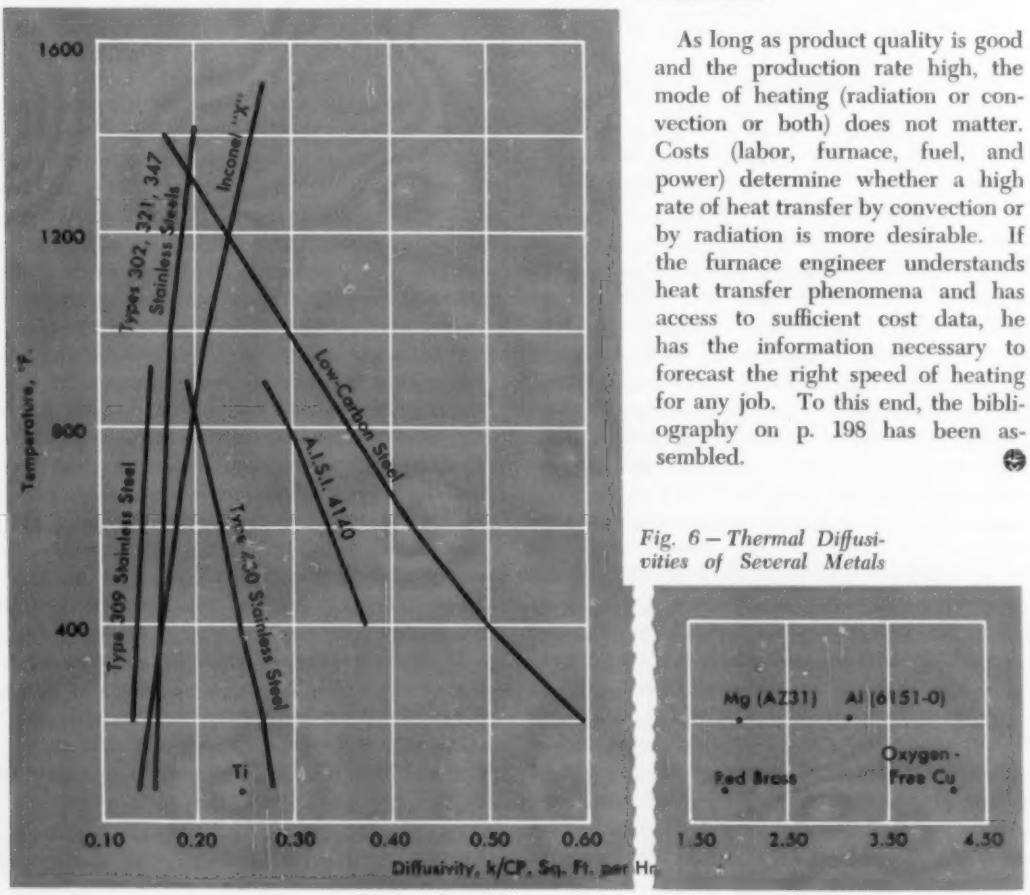


Fig. 6 — Thermal Diffusivities of Several Metals

Modernization in Heating for Hot Forming

*By PHILIP W. MORSE**

Sixty-cycle three-phase current can economically heat billets for forging, upsetting or extrusion. After the magnetic change point is passed, 960-cycle coils – dual purpose – carry the temperature higher. Higher frequencies are used for smaller billets. Several completely automatic systems are described. (F21b, W28s; ST, Mg, 4-52)

INDUCTION HEATING prior to hot forming has had a curious evolution. The cart came before the horse. Until quite recently only high-frequency motor-generator equipment was used, and its cost hindered wider use. Sixty-cycle current did not come into its own until about six years ago, and by that time the use of higher frequencies had a 15-year head start, and many of the early problems had been worked out. Nevertheless, progress in 60-cycle induction heating was rapid, in good part due to the solid engineering experience already gained. The result is that the complete spectrum of frequencies, 60 through 450,000 cycles, is now available.

Sixty-cycle equipment does not replace or displace other heating frequencies for billet heating, but it does substantially enlarge the choice of available equipment for heating large and small metal masses. The new, low-cost equipment, used alone or in dual frequency combinations, is now competitive in cost with fuel-fired furnaces. Its easy incorporation into a production line which is so important to industry today, can deal with larger pieces than was economically feasible with high-frequency equipment. Installations which deal with large metal masses in a high rate of production justify more elaborate material handling and control equipment. Some of these will be described later.

There appear to be three important elements to consider: The first is automatic handling of parts between manufacturing operations. The second concerns handling of the part during heating. Third is control to give the desired heat pattern to the part. The resultant combination depends upon which is most important in the particular job. Briefly, the advantages to consider are lower production costs, increased production per machine, improved quality of each part, added plant safety, and improved working conditions. The inherent advantages of induction heating are speed of heating, over-all economy, cleanliness, adaptability, exact control, minimum metal loss, increased die life.

Selection of the optimum current frequency is not always easy; it depends upon a number of interrelated factors. Billet size and shape is always an important consideration. Each metal has its own electrical characteristics. Desired rapidity of heating will influence the choice of frequency, yet coil design and desired heating

*General Sales Manager, Magnethermic Corp., Youngstown, Ohio. This paper was prepared at the request of the Industrial Heating Equipment Assoc. and presented at the I.H.E.A. meeting during the National Metal Congress, Chicago.

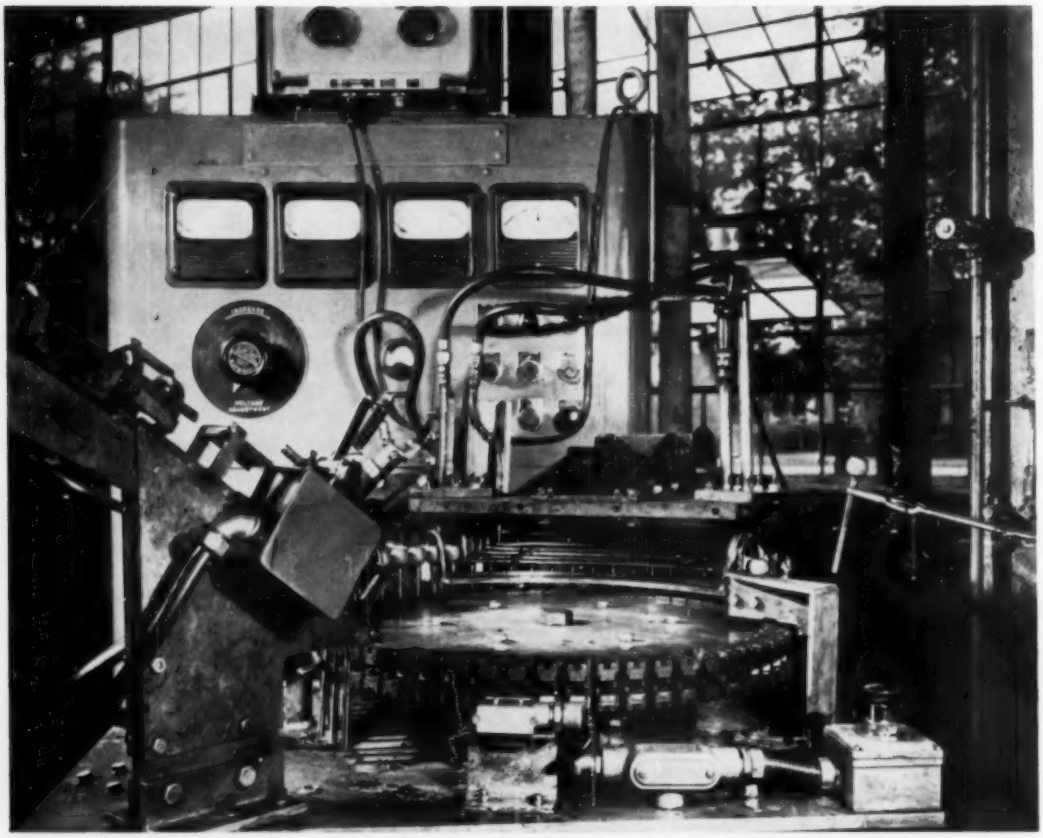


Fig. 1 – Rotary Table for Delivering Partly Formed Valves to a Channel Type of Coil and Thence to the Operator's Tongs at Right. (Courtesy Westinghouse Electric Corp.)

rate may be incompatible. All these things enter into the choice of frequency, but certainly it would be foolish to use a higher frequency if a lower frequency works just as well. It is as simple as this: High-frequency or motor-generator equipment costs $70 to $110 more per kw. than apparatus for 60-cycle or line frequency. Yet low frequency is not the whole answer. Sixty-cycle inductor coils for carbon and stainless steel billets below 4-in. diameter have such poor efficiency at temperatures above the Curie point (or magnetic transformation) that the lower initial cost is more than counterbalanced by the higher power consumption.

While it was once thought that high-frequency single-phase generators required inductor coils with fewer turns and less amperage than the 60-cycle coils, the perfected art of making polyphase coils in the low-frequency range has removed these early objections. The magnetic flux can be essentially uniform through the length of the coil. Coil vibration is no longer a problem at 60 cycles. Motor effect,* once considered detrimental, often can be used to advantage in polyphase coil design. The old criterion that the diameter of the workpieces should be six to eight times the depth of power penetration (defined as the depth at which 87% of the power is absorbed) is no longer true. Over-all cost of operation, more rapid heating, greater temperature uniformity in shorter time, must also be considered. Dual-frequency techniques may change the current conditions when steel, for example, changes from magnetic to nonmagnetic state. While such equipment is relatively new, old single-frequency installations are being modernized and doubled in capacity at the

*The tendency for nonmagnetic loads to be thrust out of the coil (and magnetic loads to be pulled in) when power is turned on.

original cost of the low-frequency equipment and handling or other auxiliaries.

Many induction heating installations for hot forming are located in geographical areas where natural gas or oil is very cheap. Aluminum billets, for example, are heated for extrusions where costs on the order of 25 to 1 in favor of natural gas exist.

How, then, does the user of induction equipment justify it? Savings in production down-time, improved temperature and process control, minimum delay in start-up or in changeover in billet size, simpler material handling, less material in process, less over-all maintenance, opportunity for complete automation – these are the more important elements which put fuel costs in the background. Savings in scrap and in production down-time often pay for the difference in capital and operating costs.

Equipment – The actual heating coils are so inconspicuous they are usually overshadowed by cabinets containing the electrical equipment and the ingenious feeding and delivery systems. A typical installation consists of properly insulated coils arranged side by side, open at both ends with bars fed into each by chutes and pushers. The program is arranged automatically to avoid overloads on the electrical supply, each piece being heated in the proper region to proper temperature, then ejected to a conveyer leading to upsetter, press or hammer. Coil "libraries" provide for quick change-over for larger or smaller billets. Discharging equipment is controlled by time cycle or radiation pyrometers.

A variation of this idea has loading devices to keep an inclined conveyer constantly full, down which roll the round bars through a flat, channel type of induction coil. One such installation heats 7½ in. on one end of a 1.31-in. round, 19 in. long. When such equipment is set to produce at a steady rate it is well to measure the temperature of each bar with radiation pyrometers as it ends the heating cycle; any which fails to meet specifications can be automatically diverted. Complex, specialized handling mechanisms are well illustrated in Fig. 1, one of three induction forging heaters producing 3600 exhaust valves per hr. The heating operation is completely automatic. Valve blanks, previously upset to an "onion" shape, are delivered by a slide conveyer to the left in this photograph. The magazine transfers each valve to a clip in the continuously moving turntable. After the controlled heat cycle, the selectively heated blank is cleared from the table clip at the right and delivered to the press operator. You will see the multi-turn channel-type coil at the back of the turntable. A transfer mechanism to the press die would complete the automation of this process.

Figure 2 shows the discharge end of an automatic machine for heating the end of a 1.37-in. tube prior to upsetting a flange. Stock is elevated by a chain conveyer to the inclined chute seen at the top of the photograph leading into a transfer mechanism at its lower end, which places them alternately in the left or right coil. At the end of the heating cycle a pusher mechanism advances and ejects the tube, which falls into the V-trough ready for the upsetter. The reason for the double coil and alternation is to make good use of the power, since at any time one tube is below the Curie temperature and the other is above.*

Cleanliness is evident in the view, Fig. 3, of a dual-frequency induction heater at a large forge company near Chicago. It handles 6000 lb. per hr. of steel billet. The heating coils are covered, but consist of 500 kw. of 60-cycle equipment in the preheat section for bringing the work up to 1300° F. and 500 kw. of 960-cycle power to heat the rest of the way to forging temperature (2300° F.). The induction equipment is completely integrated with control, capacitors and material handling equipment in one unit. Generators are located in a room to the rear. The view is from the operator's position. The conveyer at the right takes the cold billets to the far end of the equipment where an escapement feeder charges the furnace at the 60-cycle end. This equipment is designed to handle billets from 2-in. to 4-in. round-cornered squares; it can also handle slabs with a cross section of 2½ × 8 in. You will note the "rayotube" at the discharge end for monitoring the billet temperature.

Large Production – Equipment for considerably larger steel billets is shown with covers removed in Fig. 4. The two coil lines, each rated at 1500 kw., heat 50 7 × 7-in. billets, 14 in. long, every hour to forging temperature. There are six coils to each line, two coils per 60-cycle phase. Approximately 14 billets are needed to fill each line. Transformers, power factor correction capacitors, and the necessary controls are

*A dual-frequency double-tunnel heater for a Canadian merchant mill is described by R. S. Segsworth in *Metal Progress* for October 1957, p. 129.

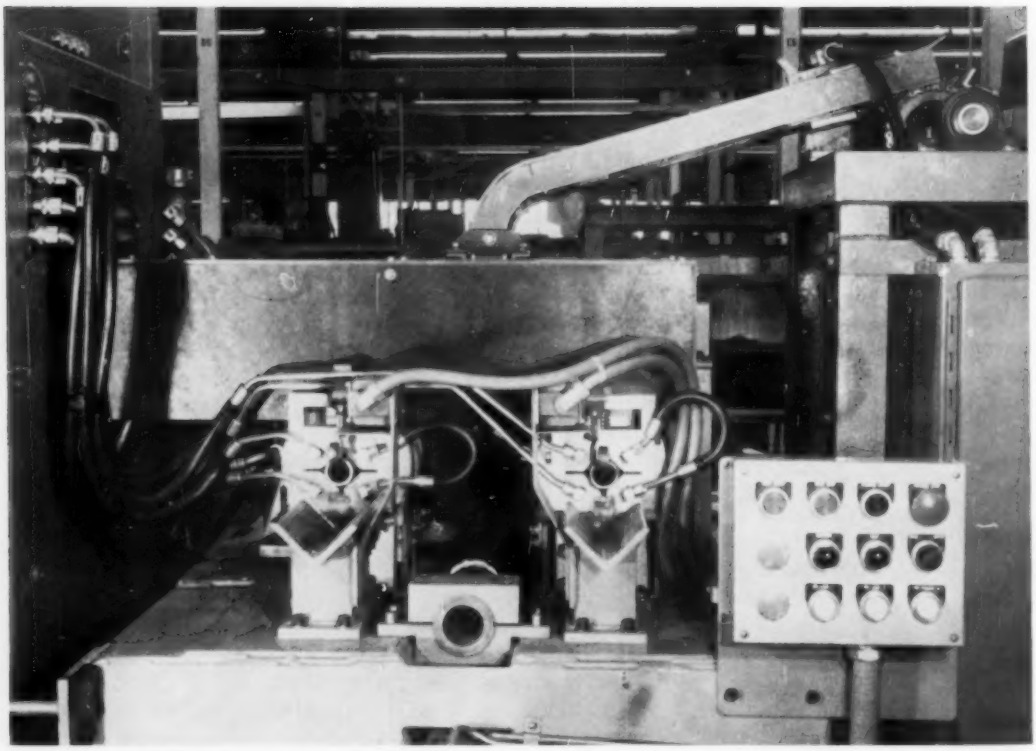


Fig. 2 – Delivery End of Machine for Heating Ends of Tubes for Flanging. Tubes are fed alternately to coils, so one is heated up to the Curie temperature while the other is getting up to forging heat. (Courtesy Ohio Crankshaft Co.)

located in the cubicles below. This view shows the charging end of the heater.

Billets are conveyed to the roller line whose end is barely visible between the two pushers fed alternately to one side or the other, tilting 45° at the same time. Charging cylinders then push the billet into the induction coils. At the discharge end, the material handling process is reversed, and they are conveyed to the forging press. At the discharge end are radiation pyrometers. In the right foreground is the cubicle for control instruments.

In-line production such as this requires adequate controls to charge the furnace at the beginning of the day as well as to empty it at the end. The equipment must adjust to hold-ups in production; delays are inevitable. Finally, because induction heat is high-speed heat, extremely accurate control of power is necessary. Low-frequency induction puts heat energy into the piece at a much greater depth than higher frequency does, heating time is proportionately less, and temperature control, as a consequence, takes on even greater importance.

What does all this give to the user? An automatic billet heating operation with no guesswork, with relatively little material in process, with immediate response to the production delays, and with billets at correct temperature.

When the forging press is ready to accept billets, all the operator has to do is press the "start" button of the billet heater. Assuming that the equipment is starting up in the morning, billets will be fed alternately into the induction coils at the charging end. As each coil is filled up, power is applied automatically to the coil. This process continues until all six induction coils are filled in each line. Finally the equipment delivers a billet at correct temperature to the heat soaking chamber at the far end of the line. At this point the equipment goes automatically into "hold". Billets remain stationary and power is applied intermittently and automatically in each coil to make up for heat losses. All this is monitored by the radiation pyrometer. When

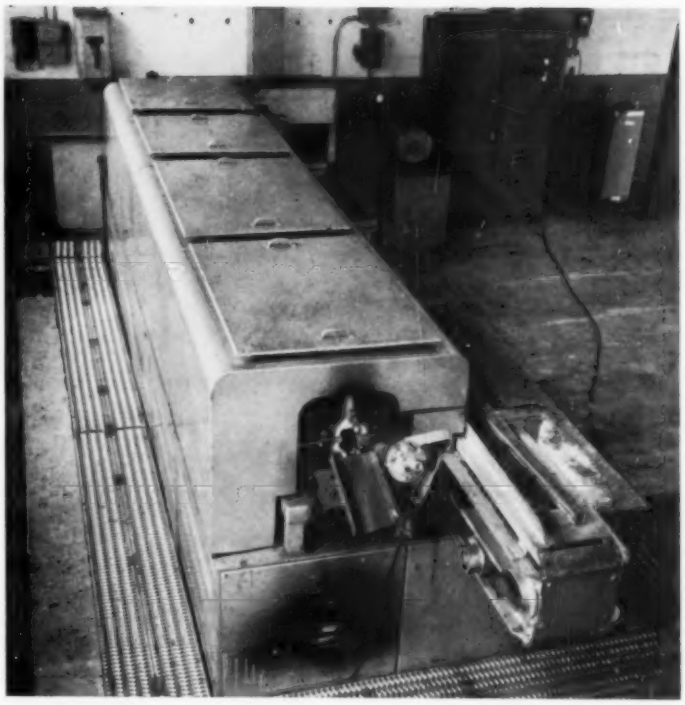
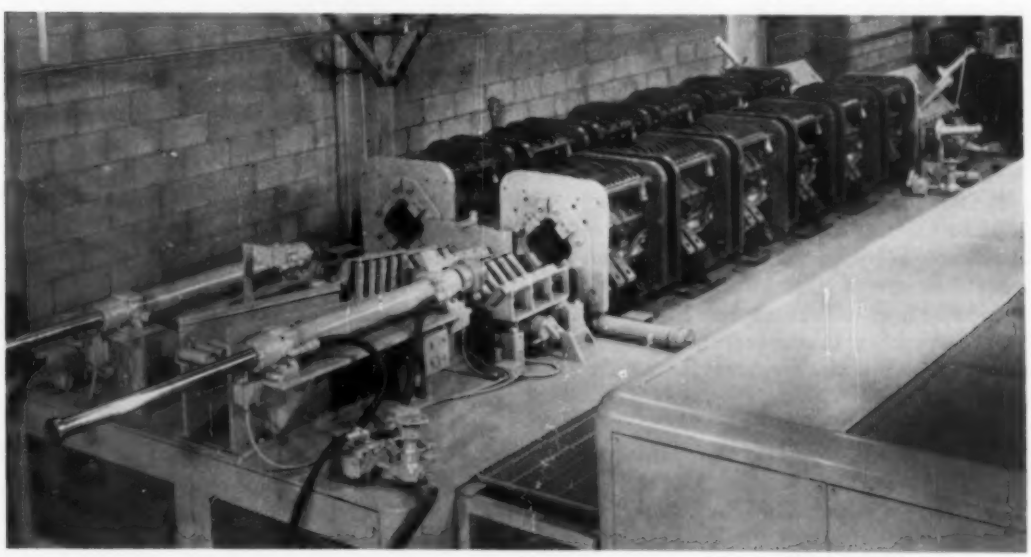


Fig. 3 – Dual-Frequency Conveyerized Billet Heater Rated at 6000 Lb. per Hr. Cold Stock is loaded on conveyor at right, enters heater at far end, and is discharged a step from hammerman's position. (Courtesy Magnethermic Corp.)

the press is ready to accept billets, the operator presses the "run" button. Heated billets are then delivered every 36 sec. to the forging press – every 72 sec. from each coil line. This is the full rated output; the equipment will deliver less if required. If for any reason the billet is either too hot or too cold, the heater automatically rejects it. At any time the operator can place the billet heater in "hold" position. Thus the equipment adjusts to production delays developing elsewhere in the plant.

A unique control system, determined by a kw-hr. relay, literally measures the amount of energy that is induced electrically into each billet. Billet speed through the induction coils is regulated by this information. Additional adaptability in the equipment is provided by

Fig. 4 – Double Coil Line, 1500-Kw. Each, for Continuous Heating of 7 × 7 × 14-In. Steel Billets With 60-Cycle Three-Phase Current, Two Coils for Each Phase. Capacity, one billet each 72 sec. from each tunnel. (Courtesy Magnethermic Corp.)



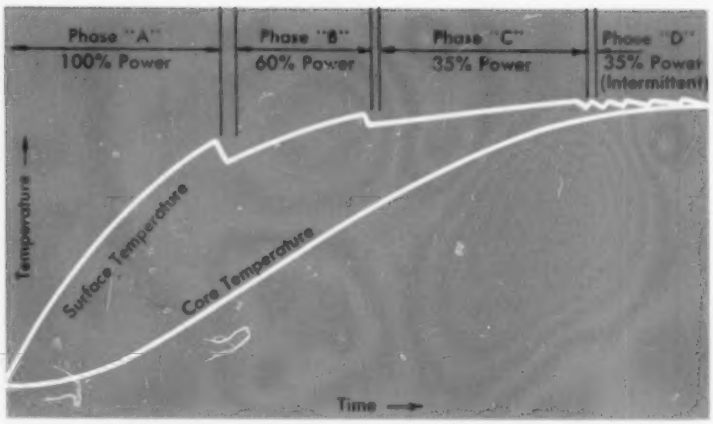


Fig. 5—Representative Time-Temperature Curves for Surface and Core on Cross Section of Large Magnesium Billet Heated for Extrusion

taps on the power transformer. Together they provide ready control of the production rate and final billet temperature.

Heating Magnesium — A beautiful example of complete temperature control and effective handling of large billets is at the plant of a large magnesium producer. The large extrusion press here takes magnesium alloy billets 32 in. in diameter and weighing about two tons.

Billets arrive on roller conveyors and are stopped in front of one of three heaters, upended, and raised into induction coils. These are large editions of the coils shown in Fig. 4, and also receive 3-phase 60-cycle current. After properly heating, the huge billet is lowered, tilted over onto a transfer table and travels about 100 ft. to the 13,200-ton extrusion press. This action is automatic and synchronized with the requirements of the press. The entire installation runs into many millions, and its economic operation permits no delays due to off-temperature billets or failure to deliver when the press chamber is empty and waiting.

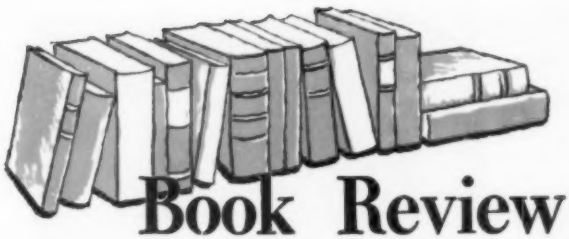
Some 26 motors are included in the temperature control and transfer equipment, backed up by over 200 relays in the circuits. Although the material handling and automatic heating are vital to its success, temperature control during the heat cycle plays an equally important role and is accomplished only through the use of induction heat. Not only is it desirable to heat these large magnesium billets as fast as possible, but it is also important for the temperature differential between the surface and the center to follow a definite prescribed path, such as shown in Fig. 5. Otherwise, hot shorts, incipient melting, and cracks develop on the surface. During each phase A, B, and C of the cycles, motor-operated tap switches change the power density of the coil to a preset amount with respect to the top, center and bottom of the billet. Thus, we can not only control accurately the surface-to-center temperature over the entire heating range, but also produce a billet with a tapered heat pattern along the axis — hottest at the rear end of the billet which will be extruded last.* The saw-tooth pattern, phase D, at the surface after the billet reaches extrusion temperature shows how easy it is for the induction heater to hold the temperature through intermittent application of power until the press indicates its requirement for another hot billet.

Now, what does the operator have to do to keep all this going? Almost nothing. Once the tap-changing controls of the power transformers are preset, the induction heater sees to it that the billet reaches proper temperature and holds the billet at that temperature. Either the press or the press operator releases the billet from the heater at the proper time. The coil is then automatically recharged with a cold piece of metal.

Conclusion

New over-all concepts as to production, the wide spectrum of frequencies now available, new techniques in process and temperature control, and recent progress in material handling equipment add new dimensions to induction heating for hot forming. Where mass heating is a requirement, there is not a single metal or alloy that does not fall under the spell of induction heat and its amazing possibilities for plant modernization.

*The advantages of "taper heating" of large aluminum billets for extrusion were discussed by A. J. Mueller in *Metal Progress* for February 1957.



Book Review...

A Definitive Study of Aircraft Fatigue

Reviewed by *LEO SCHAPIRO**

FATIGUE IN AIRCRAFT STRUCTURES, Edited by A. M. Freudenthal, Academic Press, Inc., New York, 1956. 446 p. $12.00.

IF YOU DID NOT HAVE the opportunity to attend the three-day international conference in early 1956 at Columbia University, of which this well-edited book is the proceedings (I too was among the unfortunates) you will at least benefit by this account. Much of the enthusiasm of the international specialists in this field should brush off as you read their presentations and also their discussions.

While the conference was planned primarily for specialists in fatigue in aircraft structures, the theoretician, the physicist, the test engineer, the metallurgist—in fact anyone even mildly interested in the subject of fatigue—will enjoy reading the first eight chapters dealing with the physical theories of fatigue. If you are among those who still doubt that fatigue cracking actually does occur very early in a loading spectrum, even though cracking is not visibly progressive to rupture, here you will find ample evidence to gnaw at your doubts.

Well-made micrographs from light and electron microscopes literally lead you by the hand. They show that fatigue failure, as we commonly speak of it, is a statistically measurable phenomenon that we do not measure too accurately. You may even be surprised to learn from one of the international specialists that in his opinion the test machines with which most of us measure fatigue strength of specimens or parts are themselves contributing a very large part to the scatter all of us experience in fatigue testing. Here are no proven rules which say that scatter in life at any stress level is normal or log normal, or that scatter in stress at any lifetime is normal or log normal. But data in considerable numbers are available for whatever further detailed study you may wish to give the subject.

Here, too, is food for thought for the experimenter who has always presented his test results as S-N semi-log diagrams but today wonders whether to use the newer log-log diagrams or probability paper about which he is hearing more lately. Even after reading this section of the book the experimenter will find that his selection will be his own choice, but he will have plenty of morsels to chew upon before he makes up his mind.

The remaining chapters of the book are strictly for aircraft engineers and, in fact, will be of interest of those dealing principally with certification of newly designed airplanes. Substantiation of airworthiness in flight environments causing fatigue loading is discussed from many viewpoints. Shall the laboratory fatigue tests attempt to duplicate fully the complete gamut of spectrum loading which can be predicted for flight environment or does some arbitrary loading spectrum adequately represent airworthiness? As in politics, the answer is interpreted on the basis of each nation's approach to the problem, and all differ widely.

As well, different views are maintained by specialists in any one country. And here in the 270 pages, all views are presented for the reader to ponder and ultimately take his choice. Fail-safe design and no-failure design are discussed thoroughly. Added factors for fatigue loading superimposed on present-day static factors are also treated fully.

All chapters of this book should interest the aircraft engineer who is concerned—even remotely—with fatigue of metals, metal components and assemblies, since it effectively expresses the latest experience of specialists of the free world.

*Chief Metallurgical Engineer, Santa Monica Div., Douglas Aircraft Co., Inc., Santa Monica, Calif.

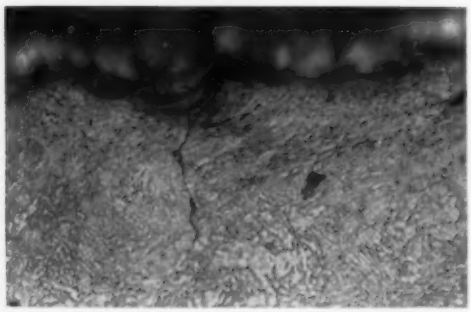


Fig. 1 – Cold Worked Surface With Folds From Which Fatigue Cracks Start. Steel forging with decarburized and shot blasted surface. 500 ×; 2% nital etch

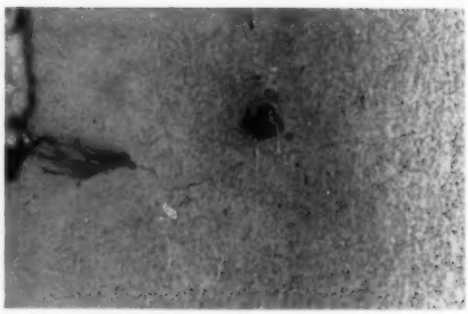


Fig. 2 – Low-Carbon Steel Piece With Shot Blasted Surface. Fatigue crack related to small inclusion joins up with others starting at surface fold. 250 ×; 2% nital etch

Damage by Uncontrolled Shot Blasting

*By KONRAD KORNFELD**

IMPROVED fatigue resistance after shot peening has led some to assume that shot blasting (primarily a cleaning process) may substitute for shot peening. The main similarity is that shot is thrown against the surface of the metal part. Apparently shot peening must be limited to optimum process factors, experimentally obtained, and controlled by the use of Almen test pieces which prove that the settings are within the specified limits.

On the other hand, shot blasting for surface cleaning depends upon the operator, who is primarily interested in the resulting surface color. As long as the dimensions are not affected by excessive abrasion, the inspection is usually satisfied. Nevertheless, the examples indicate that the metallurgist should pay some attention to this cleaning process.

The first example (Fig. 1) is a steel forging of 190,000 psi. ultimate, descaled by shot blasting after the heat treatment, resulting in a surface finish of 55,000 to 140,000 micro-inches, from which it was estimated that No. 8 U.S. standard sieve shot (0.0937 in. diameter) was used. Knoop surface hardness tests indicated that the force exerted on the shot was about 110 lb. per globule.

The surface of the forging had been decarburized and its hardness, even after work hardening by shot blasting, did not exceed 275 diamond penetrator number, corresponding to 131,000 psi. ultimate. The flow of the material and the tendency to form folds by shot blasting are quite obvious from Fig. 1. This also shows a fatigue crack from a fold which spread during service.

Examination of this piece failed to find the fine fatigue cracks by either magnetic particle or penetrant dye inspection, since they were hidden beneath folds in the decarburized surface.

The second example is a low-carbon steel of 74,000 psi. ultimate strength. The steel was cold formed and of spheroidized microstructure. It was shot blasted to preclean before cadmium plating. Owing to the low hardness, the plated steel was not baked to drive off hydrogen.

Figure 2 shows some subsurface cracks seen when the unetched test piece was slightly out of focus. Such cracks were usually associated with small inclusions. The crack in Fig. 2 started at an inclusion (washed off by etching) and spread into a bunch of large cracks ending at a surface fold.

The surprises which may be due to uncontrolled shot blasting are not exhausted by these two examples, but the danger from forming cracks and folds appears obvious when stress raisers must be avoided. The uncontrolled amount of work hardening may be also harmful if not anticipated, as shown by the low-carbon steel of Fig. 2.

*Ottawa, Canada.

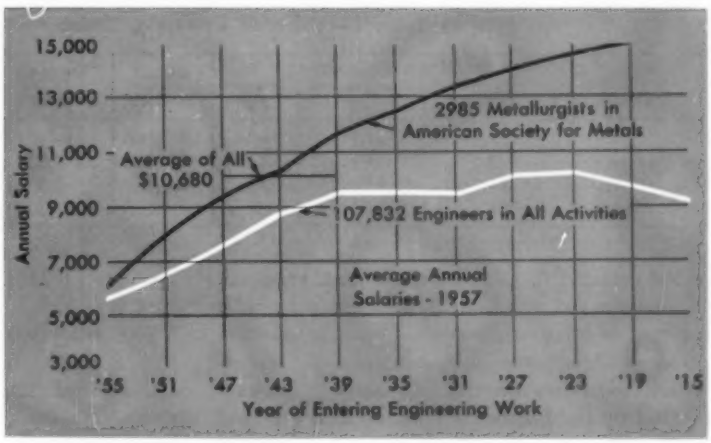


Fig. 1—Salaries of "Professional" Engineers (White Line) as Compared to Metallurgists and Metallurgical Engineers (Black Line). Authorities: Engineers Joint Council questionnaire sent to basic mailing list of the Engineering Manpower Commission in July 1956; American Society for Metals questionnaire sent to all its members classed by Audit Bureau of Circulation as "metallurgists" and "metallurgical engineers" in April 1957

Salaries of Metallurgists

By WALTER MORRISON*

A survey of all ⊜ members classed as metallurgists or metallurgical engineers shows that, on the average, starting salaries measured in present-day purchasing power have steadily increased since the depression years, and as much as 45% since 1949. Their salaries are considerably higher than those of the 108,000 engineers surveyed in 1956 by Engineers Joint Council. (A6q)

WHAT DO metallurgists earn? In the United States and in 1957 dollars, that is. You have to know that to know whether it would pay the bright young man or woman to spend at least four more years in scientific or engineering college, costing them somewhere between $3,000 and $12,000†, when they can immediately get a well-paying job in some plant.

What does a metallurgist earn? The ⊜'s Advisory Committee on Metallurgical Education asked all members of the American Society for Metals about this in the early summer of 1957. Questionnaires were mailed to 5,861 members, all those who are classed in ⊜ records, as audited by the Audit Bureau of Circulation, as "metallurgists" or as "metallurgical engineers". Of these, 2985 responded, a return of 50.9%. The present writer, who serves as staff secretary

*Staff Member, American Society Metals; Secretary of the Advisory Committee on Metallurgical Education.

†The low figure representing costs to a student residing at home and attending a state university; the higher figure a cost to a student at an "Ivy League" university.

Table I – Value of University Training

Higher Education	Working Life			Gross Income	Cost of Education	Net Income	Value of Education
	Age at Start	Age at End	Years				
None	18	62	44	$415,300	—	$415,300	—
B.S. (4 yr.)	22	62	40	452,500	$ 6,000	446,500	$31,200
M.S. (5 yr.)	23	62	39	464,100	7,500	456,600	41,300
Ph.D. (7 yr.)	25	62	37	498,600	10,500	488,100	72,800

of the committee, analyzed the returns received.

How do the resulting figures compare with the pay of other engineers? This is a question of some importance since a survey of "professional" engineers' income published in January of 1957 by the Engineers Joint Council reported such modest returns ($10,000 per year on the average for all engineers after 20 years of experience) that *Business Week* of July 27 quoted "a leading university guidance counselor" as issuing a warning to heads of families who are inclined to steer their teen-age sons into engineering colleges, since "engineers simply don't fare as well as you might expect".

Results of these two surveys are summarized in Fig. 1. The graph shows that the average metallurgist (🌐 survey) is paid considerably better than the average engineer (Engineers Joint Council survey). A beginner now starts off $500 a year higher; metallurgists with 10 to 20 years' experience get $2,000 a year more; and metallurgists with longer service, on the average, get increasingly higher salaries whereas the average engineer has passed his peak of earning power.

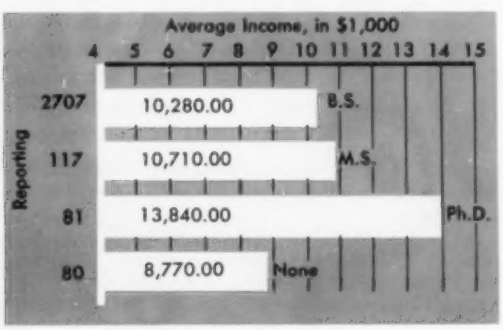
Education – Figure 1 shows that the "average" metallurgist or metallurgical engineer starts out at a fairly good figure, that his salary increases continually with years of experience and that, on the average, he now gets a salary of $10,680 per year. This "average" man is a curious complex.

For example, take his educational background. Fig. 2 shows that 2707 ASMembers reported Bachelor of Science degrees, with a present average salary of $10,280. (The highest salary for a holder of this first degree is $33,000.) Masters reporting numbered 117, with an average annual salary of $10,710, and the highest in this category gets $36,000. Ph.D.'s are better paid; 81 reported, with an average annual salary of $13,840 and the highest salary reported in this classification is $50,000. Of those who replied, 80 did not report any college degree. Their average annual salary is $8770, with a high of $24,000.

These returns can give an idea of the minimum dollar value of a college education, on the assumption that the 80 non-graduates are earning at least as much at engineering as they would at some trade – otherwise they would be foolish not to make a change.* In Fig. 3 is plotted the average yearly income of the four classes varying in educational background. Table I gives the estimates where the figures in the column "Gross Income" represent the areas under the respective curves. Education costs are assumed as $1500 per year. From the last column in the table it would appear that the student gets $7500 to $10,000 back for each of those years.

In appraising the figures in Table I it should be remembered that the curves on Fig. 3 are free from the valid objection that the *average* annual salaries reported two paragraphs above are weighted down by the relatively large number of younger men among the 🌐 membership and those responding to this survey. For example, when the entire 2985 respondents are ranged in order from highest salary to lowest, the 745 comprising the lowest quarter had an average salary of $7417, but their average length of employment was only 3.6 years.

Fig. 2 – Average Income in 1957 for Metallurgists and Metallurgical Engineers, Segregated as to Educational Background



*Likewise their average salary is $8770 whereas the U.S. Department of Labor recently announced that the "average factory wage" is $82.16 a week or $4110 for a 50-week year.

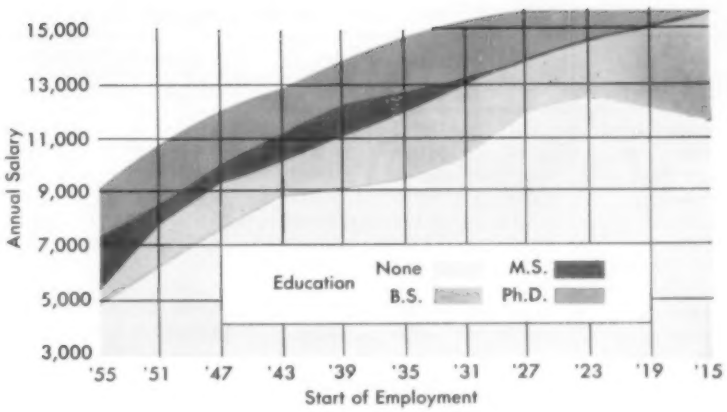


Fig. 3—Salaries of Metallurgists and Metallurgical Engineers as They Vary With Experience and With Educational Background.

Type of Work—Figure 4 summarizes the returns according to principal duties.

Actual entrance salaries for men now working as metallurgists and metallurgical engineers were lowest in the depression years, and were about $100 per month. This was low enough, in all good conscience, but one should remember that these were 1932 dollars and each dollar then would buy as much as two do in 1957. Figure 5 charts in white line the actual entrance salaries reported on the questionnaires, and the black line indicates the values in 1957 dollars. It will be observed that the entrance rate in actual purchasing power (black line) has risen steadily from about 2100 1957 dollars in 1927 to about 4400 1957 dollars in 1955. This consistent steady increase for 25 years has shot sharply upward in the last two years—a fact not shown in the trend line in Fig. 5 owing to the change in horizontal scale at the year 1955.

Experience—The following tabulation shows present incomes received according to the date of the engineering degree received.

Date of Graduation	No. of Replies	Highest	Average Present Salary
1920 to 1925	182	$50,000	$14,770
1926 to 1930	208	45,000	13,682
1931 to 1935	311	46,000	12,704
1941 to 1945	488	25,000	10,410
1946 to 1950	790	33,000	9,300
1951 to 1955	624	25,000	7,447

The last column of this table corresponds to the black line in Fig. 1. Graduates of 1956 are now receiving (on the average) a little more than

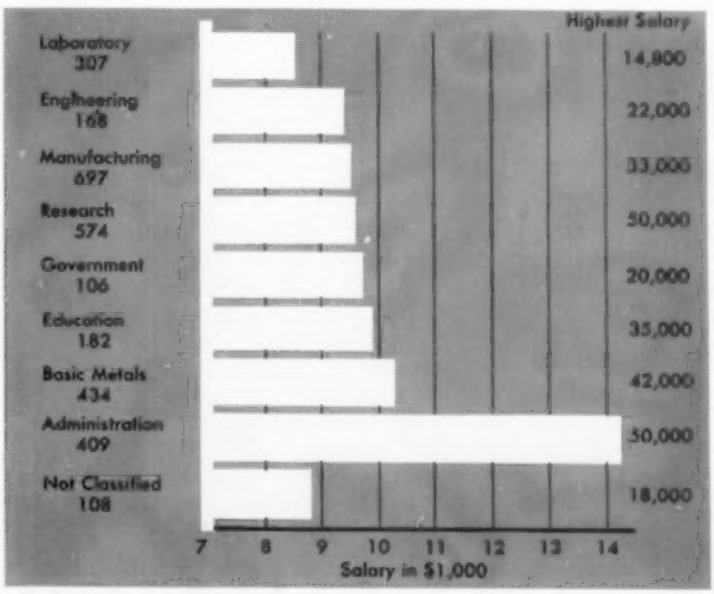


Fig. 4—Average and Highest Incomes Reported in the Various Branches of Metallurgy

Table II – Some Data Classified Geographically

State	Replies	Average of all	High	Average Salaries	
				In Research	In Administration
Pennsylvania	390	$11,355	$50,000	$ 9,622	$15,610
Ohio	357	10,106	42,000	9,741	13,337
New York	245	10,601	50,000	12,070	12,700
Illinois	209	9,900	30,000	9,956	11,238
California	201	9,695	25,000	13,972	11,741
Michigan	194	10,420	31,000	11,951	14,590
New Jersey	132	10,060	24,000	9,831	12,902
Massachusetts	128	10,100	45,000	9,366	16,682
Indiana	114	9,171	25,000	8,944	10,956
Connecticut	97	13,850	35,000	10,003	15,112
Ten Southern States	224	9,510	33,000	8,960	10,620

$6000 per year, and the recent 1957 crop a little less than $5000.

Geographical Distribution – 64.5% of all replies were from metallurgists working in ten of our industrialized states. Since it was observed that the highest incomes were from these states, and that these highest incomes were from metallurgists in research or administrative duties, Table II contains an analysis of all replies from these ten states with respect to the income from research or administrative work.

General Advancement

There seems to be good evidence that the average metallurgist is considerably better off in a financial way than he was eight years ago. This is based on the fact that the ⊕ Advisory Committee on Metallurgical Education surveyed the ⊕ membership in 1949 by sending 3000 questionnaires at random.* Only 916 replied, of which 630 were "metallurgists" or "chief metallurgists". The replies were classified in a different manner from the one just completed but, as before, the men occupied in administration comprised the highest paid group, and those in laboratory and testing the lowest. Results for this rather small sampling, as compared to 1957 data, are as follows:

	Administration	Laboratory	All Respondents
Average salary, 1949	$10,528	$5,095	$6,567
Equivalent, '57 dollars	12,700	6,150	7,950
Results from '57 survey	14,350	8,590	10,680

On this basis the real annual salary of metallurgists and metallurgical engineers is now about one third higher than eight years ago. ⊕

*The detailed results were printed in *Metal Progress* for September 1949, p. 344.

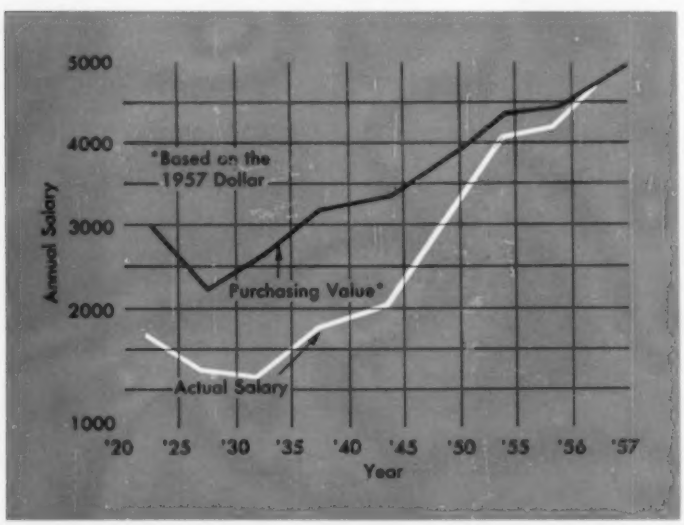


Fig. 5 – Starting Salaries for Metallurgists With Four years of Academic Training. Note change in horizontal scale for the years 1955 to 1957

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...what is being done to overcome it

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2. *A stress-strain relationship that also changes with temperatures . . .* this is a further and equally hard to predict complication with a determining effect on deformation and failure.
3. *High-temperature corrosion resistance* (especially under stress) plus the character of the corrosion product . . . these factors influence the retention of load-carrying cross section and the degree to which notches develop in the material.
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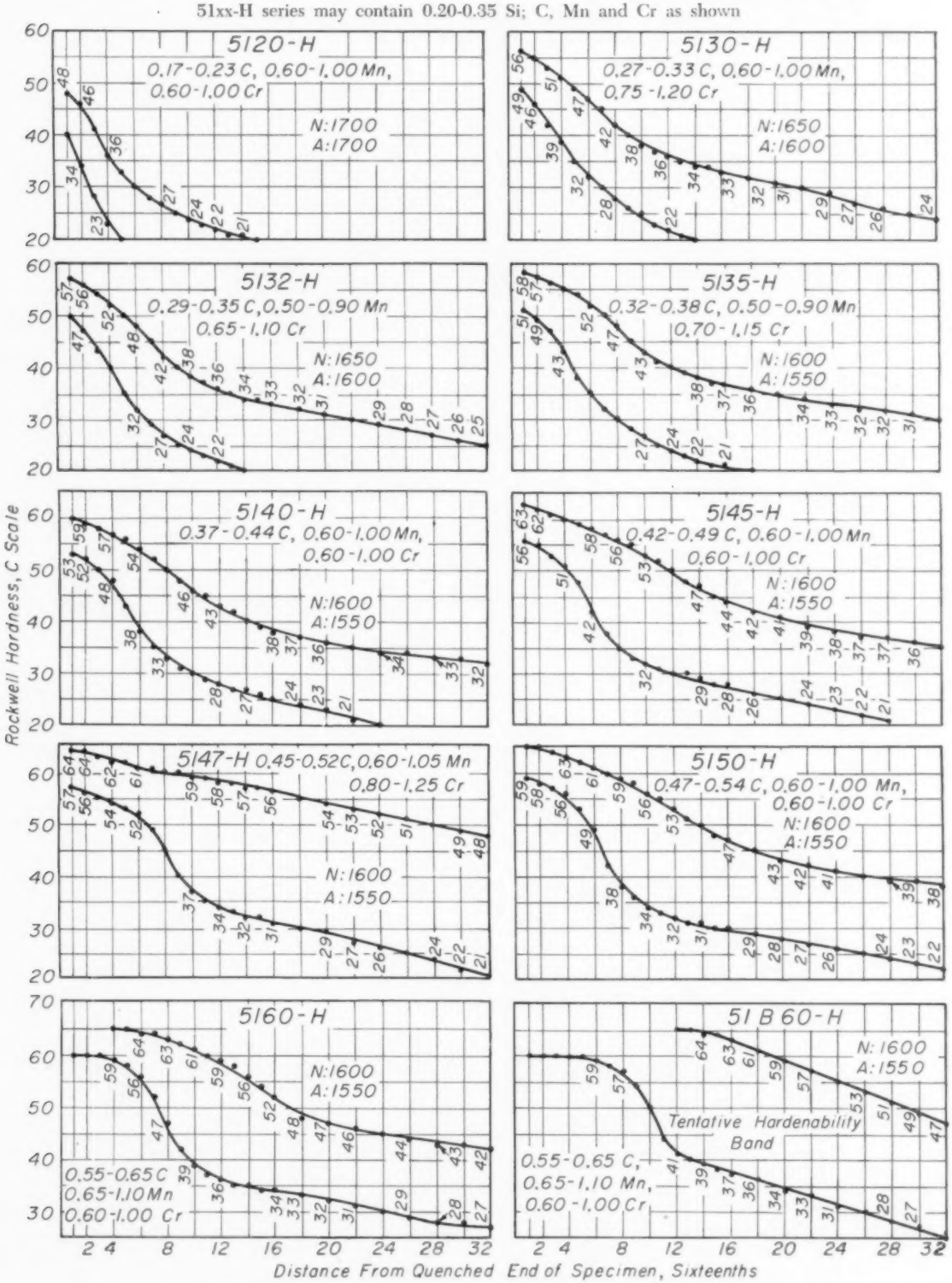

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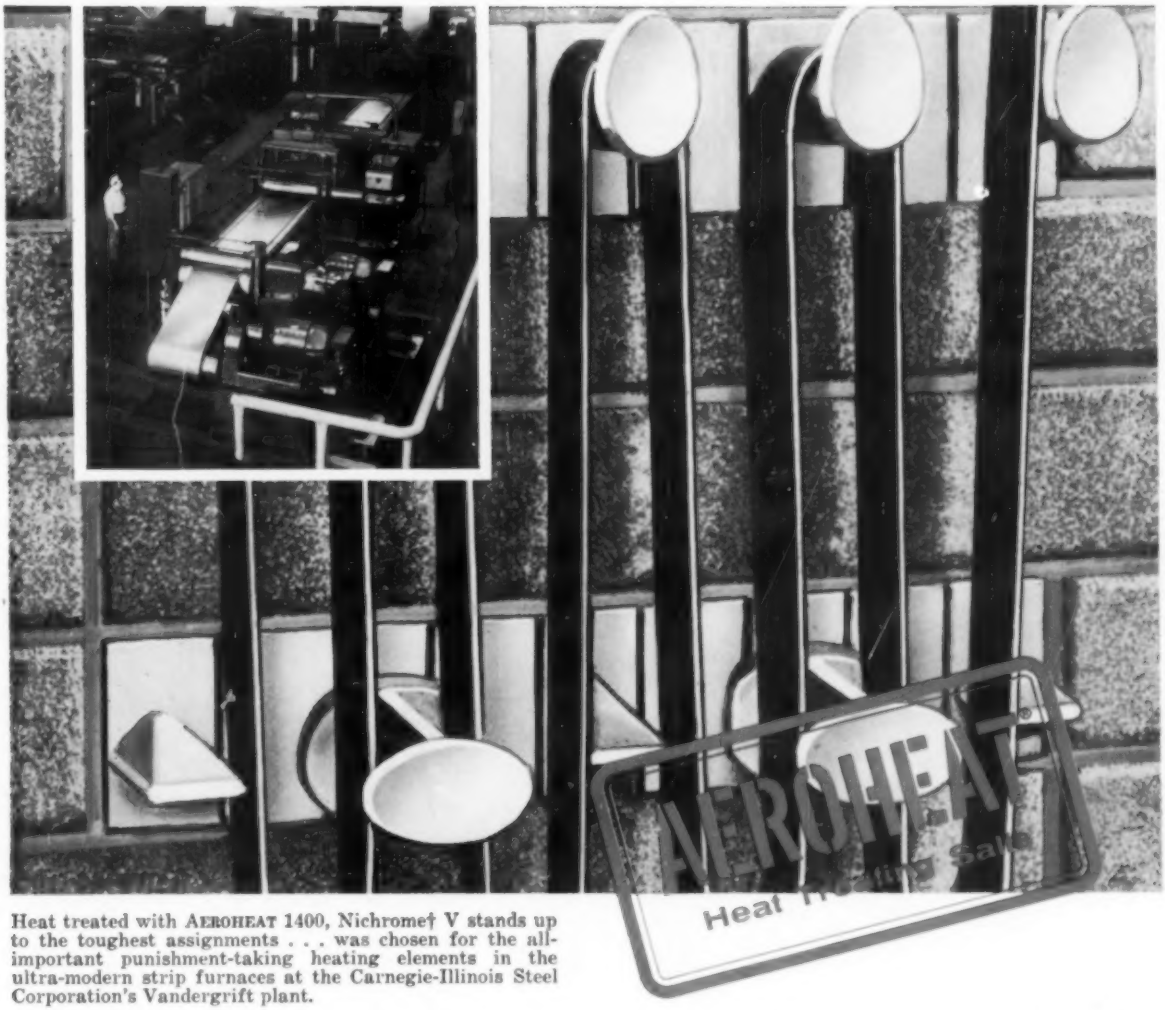

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1956 A. S. M. Metallographic Exhibit

7 BEST-IN-CLASS AWARDS

A. Nickel and 47% Zirconium Alloy

B. Type 405 Stainless Steel Brazed with Ni-Cr-Si Alloy

C. Size and Distribution of Nonmetallic Inclusions in Low-Alloy Steels

D. Carbide Skeleton Formation in a WC Plus 10% Co Cemented Carbide, as Sintered

E. Commercial Heat of A-286; Overaged Structure and Bierbaum Scratch Hardness Taken in Field of Optical Micro

F. Electron Micrographs of Irradiated Uranium

G. Scale Formed by Corrosion of Chromium in Air at Elevated Temperature

12 HONORABLE MENTION AWARDS

H. Chromium-Carbon Alloy, $Cr_{23}C_6$

I. Type 405 Stainless Steel Brazed with AMS 4775 (Ni-Cr-Si-B-C) Alloy

J. Complex Nonmetallic Inclusion in ML-1700 Alloy (Cobalt Base)

K. Zircaloy-2—Boron, as Polished

L. Zirconium-Gadolinium Oxide

M. Partial Primary Recrystallization in 3¼% Silicon Iron

N. Triangular Pattern on Bottom of Single Crystal of Silicon Probably Caused by Dislocations

O. Pearlite and Ferrite in 0.25% Carbon Steel Castings; Contact Prints

P. Wrought Iron Nail of 300 Years Ago

Q. Nickel-Molybdenum-Aluminum Alloy

R. 2¼ Cr, 1 Mo Weld Metal on Carbon Steel Base Metal, Aged 1150 Hr. at 1200° F.

S. Motion of Dislocations During Bending of Lithium Fluoride Crystal

Jean Tomlinson
Research Laboratory
Schenectady, N. Y.
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Stewart S. Smyth
Large Steam Turbine-Generator Department
Schenectady, N. Y.
AWARDS B, I

Norman J. Gendron
Large Steam Turbine-Generator Department
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AWARDS C, J

Andrew S. Holik
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AWARD D

Robert E. Smith
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AWARD E

Raymond T. Knaggs
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AWARD E

T. K. Bierlein
Hanford Atomic Products Operation
Richland, Wash.
AWARD F

B. Mastel
Hanford Atomic Products Operation
Richland, Wash.
AWARD F

Mary C. Peek
Knolls Atomic Power Lab., Schenectady, N. Y.
AWARD K

Mary C. Houle
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AWARD R

Investment Casting of Precious Metal Jewelry

*By RALPH H. ATKINSON**

Although basic principles are the same as in casting other metals, melting and casting methods for platinum, palladium, silver and gold vary considerably from those used in producing turbine buckets and machine parts. (E15, T9s, 17-57; Pt, Pd, Ag, Au)

MOST JEWELRY CASTINGS, other than those for costume jewelry, are made by the "lost wax" process. The process is extremely old, and was used by the Greeks and Chinese more than two thousand years ago. Benvenuto Cellini appears to have introduced the use of plaster of paris, in addition to raising the standard of the art and writing a chatty book, as long ago as 1568. His procedure for preparing molds can be summarized as follows: The wax model was coated with a paste consisting of two parts of brick dust and one part of finely powdered "gesso" (plaster of paris) mixed with water; when the coating was built up to a finger's thickness the mold was bound with iron wire, which was then covered with coarse "gesso" (the oversize on the sieve) moistened with water to the thickness of a knife's back. After air drying, the mold was heated over a slow fire to melt out the wax, and finally baked with a greater fire.

Molds and Models

The original pattern, which is made oversize to allow for casting shrinkage, is usually a handmade ring or other piece of jewelry. Silver is frequently used for patterns because it is easy to carve. The pattern is embedded in uncured rubber, which is then vulcanized by conventional procedures. The rubber is next cut with a sharp knife along a central plane or parting and the two halves stripped from the pattern. After cutting sprues, the equivalent of gates in large castings, and a funnel-shaped entrance for the wax, the mold is ready for making wax models. Wax models are made in a small centrifugal casting machine or with a wax injector in which air pressure is used to force the wax into the mold. The introduction of rubber molds, which have obvious advantages over nonelastic molds for casting complex and delicate structures in wax, had a very stimulating effect on the development of jewelry casting.

Investments

The investment is the refractory used for forming the mold around the wax pattern. The so-called "plaster" investment used for the casting of gold and silver alloys is a mixture of equal parts of plaster of paris and fine silica. It is a hydraulic-setting low-temperature investment which should not be heated above 1850° F.; otherwise it begins to decompose with the evolution of sulphur dioxide. This thermal instability limits the "plaster" type of investment to the casting of metals which melt below about 1800 to 2000° F. The high-temperature investments used for platinum and palladium consist essentially of fine silica powder mixed with small percentages of other constituents such as sodium hexametaphosphate. The latter serve in two

*Now retired, Mr. Atkinson was a metallurgist at International Nickel Research Laboratory. He resides in Westfield, N.J. (Third in a series on metals and techniques for jewelry manufacture.)

Fig. 1 – Rings and Clips Are Typical of Palladium Jewelry Made by Investment Casting

ways – as deflocculants to make the thick slurry of water and investment more pourable and as bonding agents to give strength after firing. The use of a deflocculant is necessary because these investments set by the withdrawal of water, and it is therefore important not to use more water than necessary in preparing the slurry.

Flasks for Platinum or Palladium

Wax models with sprues attached are mounted on a suitable base, the surface of which has been waxed to facilitate removal at a later stage. A flask or ring of heat resisting metal is placed over the model and waxed to the base; the flask, except for about ¼ in. at each end, is provided with a lining of asbestos (about 1/16 to ⅛ in. thick). The asbestos assists in the "setting" of the investment by withdrawing water. After waxing an extension, made of thick paper, to the open end of the flask, the investment mixture is poured in until the models are well covered. The flask is then de-aerated by vacuum treatment in a bell jar, which can be vibrated to speed the operation. Supernatant water, which appears after standing for a short while, should be poured off before leaving the flask overnight to develop adequate green strength. The following morning, after removing the base, trimming surplus investment and dewaxing, the flask is slowly heated to about 1500° F. in a muffle furnace for the dual purpose of burning out residual wax and bonding the investment. The flask is now ready for casting.

With "plaster" investments the procedure is similar except that hydraulic setting of the investment speeds up operations with the result that investing and casting can both be done the same day.

Hand pouring of jewelry investment castings is not possible because the flasks are made without vents or risers. Consequently sufficient pressure must be applied to the molten metal so it will drive the air before it into the porous body of the investment; a high flask temperature lessens the resistance of the trapped air. Machines used by jewelers for investment casting rely on centrifugal force for driving metal into the flasks. The rotating arm of the machine carries a crucible, a flask or mold and a counterpoise. Details of design are affected by the method of melting (furnace, torch or induction), size of batch and, to a lesser degree, the melting point of the metal.

Casting of Silver and Gold

Arms of machines for casting silver and gold rotate in a horizontal plane. Small machines are driven by a spring and the metal is melted in the crucible, usually with a torch. When the metal is ready for casting, the spring is released, causing the arm to rotate, whereupon the molten metal under the influence of centrifugal force

moves outward from the crucible into the flask. In larger motor-driven machines, there might be four arms and flasks counterpoising each other. Metal is melted in a separate furnace and poured into a crucible located on the axis of rotation, whence it is distributed to the flasks by short troughs.

Production of yellow gold investment castings probably far exceeds that of all the other precious metal investment castings combined. On the other hand, the nickel-containing white golds are generally unsuitable for commercial investment casting. Palladium-containing white golds can be used for making investment castings, following the same procedure as for induction melted palladium.

Torch-Melted Platinum and Palladium

Machines for casting torch-melted platinum and palladium are small with arms rotating in a vertical plane, probably because the arm can be started faster without spilling metal than is possible when it rotates in a horizontal plane. Crucibles are made of silica which is the only refractory capable of withstanding the severe thermal shocks in this process. Metals are melted with an oxygen-gas torch with a strongly oxidizing flame. A deoxidizer is unnecessary with platinum because the quantity of gas dissolved in the molten metal is too small to affect the soundness of the castings.

Melting palladium is more difficult despite the fact that it has a lower melting point (2829° F. as compared with 3224° F. for platinum). In an oxidizing atmosphere, molten palladium dissolves considerable oxygen which results in extremely wild castings unless a deoxidizer (about 0.1% aluminum) is used. Conversely, if a reducing flame is used, even briefly, castings will be hot torn or hot short due to pickup of silicon from the crucible. It has been found that as little as 0.003% silicon is enough to cause hot tearing. Since the melter cannot avoid using crucibles made of silica, he must take great care to maintain an oxidizing melting flame at all times. Flow meters should be used on both the gas and oxygen lines for proper control. In making a cast, a flask preheated to about 1500 to 1700° F., depending on the operator's preference and speed of working, is placed on the machine and about 2 oz. of "casting palladium" is melted rapidly in the crucible. (Casting palladium consists of strip cut into pieces of convenient size for melting.)

Fig. 2 – A Centrifugal Casting Machine Melting and Pouring Torch-Melted Platinum and Palladium. Here the crucible and flask are ready for a melt

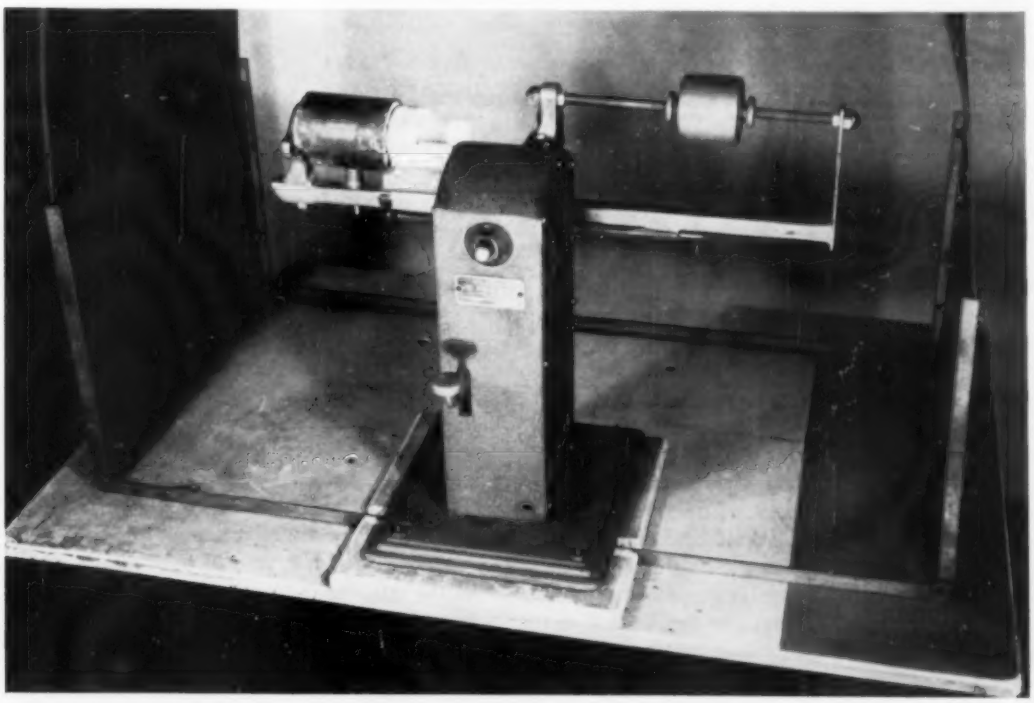


Fig. 3 – An Ecco Centrifugal Casting Machine for Casting Induction Melted Metal. The tube is used to provide an inert gas atmosphere

It will be found that the pieces of metal melt without running together, because films of alumina prevent them from coalescing. By a suitable rotary motion of the torch the small pools can be "rolled", which causes them to run together and form one large pool. Heating and rolling is continued until the surface film has been taken up by the crucible. When metal is clean and fluid enough to cast, a piece of pure aluminum foil (about 0.1% of the palladium by weight) is dropped on the surface of the melt, which is then cast by releasing the spring of the machine. The flask can be quenched in water to facilitate stripping. After removing as much investment as possible, the castings are cleaned by pickling in hydrofluoric acid.

The use of an induction melting machine for making investment castings is simpler and more certain than torch melting. In the former, the pieces of palladium readily melt together and the alumina film does not have to be removed before deoxidizing; furthermore, gassy and hot torn castings are virtually eliminated. The only reason that torch melting of palladium survives is that the much greater cost of induction melting equipment (about 20 times that for torch melting) puts it beyond the reach of the small workshops, of which there are many.

Induction Melted Platinum and Palladium

A unit which is being increasingly used for jewelry casting consists of an Ecco 6 to 8-kva. high-frequency converter and an Ecco centrifugal casting machine. One difficulty associated with the production of small castings of platinum and palladium is that the metal solidifies within about 5 sec. The Ecco machine overcomes this difficulty by using centrifugal force to transfer the metal from the crucible to the mold immediately after heating ceases.

The arm of the casting machine, which is arranged for rotation in a horizontal plane by

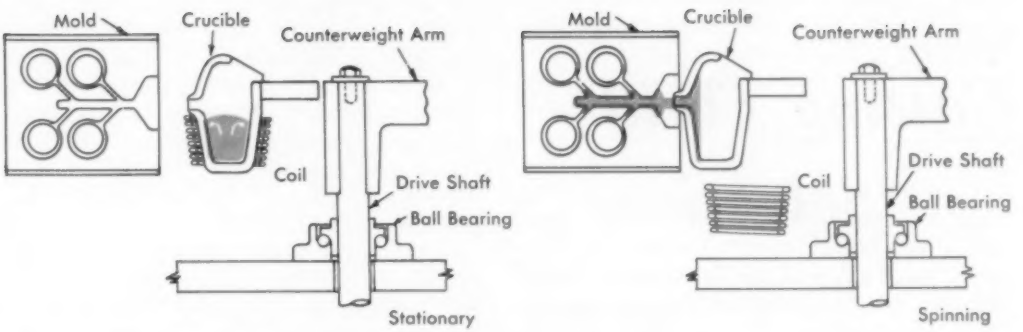


Fig. 4 – When Heating Has Been Completed in This Induction Melting and Casting Machine, the Coil Is Lowered From the Crucible Which Is Then Rotated to Force Metal Into the Mold

a ½-hp. motor, carries a melting crucible and a suitable mold supported in a cradle on one side of the axis of rotation and a counterpoise on the other. Crucibles, which are of special design, have casting outlets for the molten metal about 1 in. below the rim. An optical pyrometer, on a suitable bracket clamped to the bowl of the casting machine, is sighted on the surface of the metal for taking temperature readings. When the metal is ready to cast, the heating coil is lowered, automatically switching off the heating power, and at the same time the motor is started. As the rotating arm gathers speed, molten metal swings outward and rises up the side of the crucible and when it reaches the outlet, provided centrifugal force is adequate, it will jump the narrow gap between the crucible and mold without any metal being spilled.

Casting speed, which varies with density of the metal, should be about 500 rpm. for palladium. The effective capacity of the melting crucibles, of which there are two sizes for this machine, is limited by the necessity for allowing adequate freeboard (about 1 in.) below the outlet in order to avoid spillage during casting. In practice it is found that the melting capacity is from 2 to 8 oz. of palladium and from 2 to 15 oz. of platinum. In spite of the small size of these melts, they are production volumes. As many as 50 rings or jewelry parts can be obtained from one such melt.

The machine can also be used for casting gold and silver alloys and has also proved useful in making exploratory melts of a wide variety of nickel alloys.

Platinum and palladium are melted in so-called "platinum" crucibles, which consist of a shell of highly refractory fireclay lined with a zirconia cement. Melting and casting of platinum, which can be done without using a deoxidizer, is so straighforward that it need not be described in detail. Palladium, unlike platinum, requires a deoxidizer; about 0.05% aluminum is adequate if properly added. To prevent the aluminum from being held up by superficial oxide films on the molten palladium, the aluminum (in the form of wire and crimped to the end of a tungsten or palladium wire) should be plunged into the melt and the supporting wire immediately withdrawn. An advantage of this method of deoxidation is that clean scrap can be included in the charge, because the film of alumina which forms on molten metal need not be removed before deoxidizing.

When making investment castings of palladium, the charge (2 to 4 oz.) is placed in the crucible and melted. Next, a flask, preheated to a temperature in the range 1300 to 1500° F., is placed in position on the arm of the machine. The metal is then deoxidized with a small amount of aluminum as described above and cast when it reaches a predetermined temperature (about 200° F. superheat) by lowering the heating coil and starting the motor, as described earlier. Castings are stripped and cleaned as previously described.

Tests have shown that there is no advantage in using an inert atmosphere, such as argon, when melting palladium, probably because the charge normally contains enough aluminum to form a thin superficial film of alumina which is remarkably effective in preventing the entry of oxygen into the molten metal.

Although most melting of platinum and palladium by a manufacturing jeweler will be for investment casting, small ingots can be cast in split graphite molds for later conversion into strip or wire form.

Cutting Fluid Selection

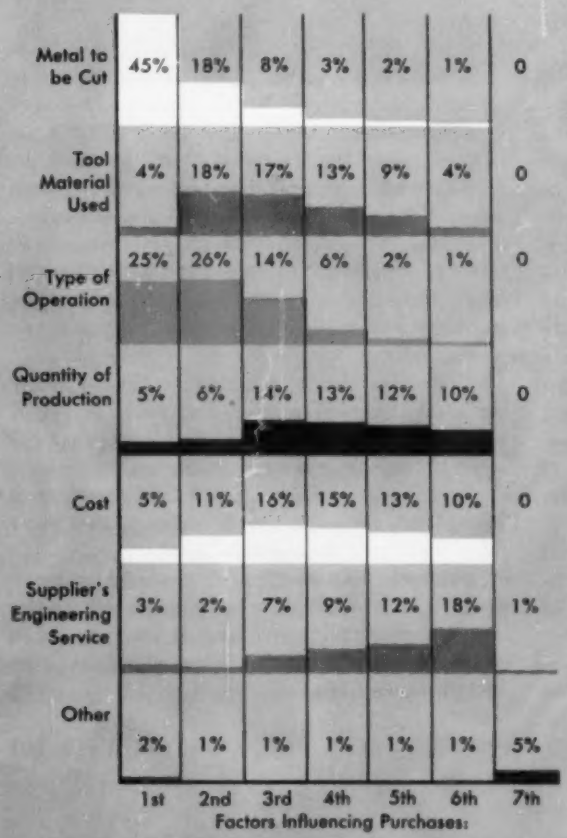
The Metal Makes the Difference

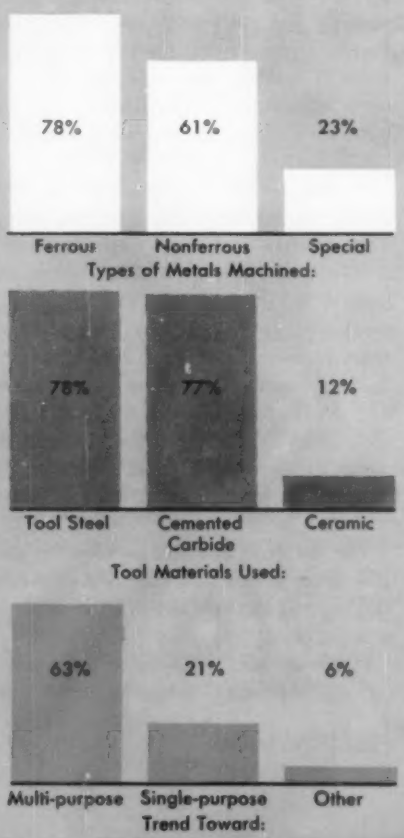
NUMBER ONE FACTOR in the selection and purchase of cutting fluids is the type of metal to be machined, according to 45% of the respondents in a study just completed by the American Society for Metals Advisory Group on Industrial Practices.

In fact, 77% of the production executives cite the metal itself as *one* of the governing factors (if not the prime factor) in the selection of the cutting fluids to be used. Type of machining operation is regarded as the most important factor in one quarter of the plants; others list cost, quantity of production, tool material used and the engineering service provided by the cutting fluid suppliers.

In order to secure this information, a comprehensive statistical study of the entire ASM membership was made and a proportionate selection was made by title (administrative, purchasing, technical or engineering, supervision, and operators), by nature of product (assembled metal products, transportation, and producers of metals) and geographical location. This sampling amounted to slightly over 500 men having 93 different titles and residing in 23 states. Each of them was sent a one-page questionnaire; 58% responded. A statistical analysis of the replies indicated that the responses did not favor any particular location, type of plant, or function or title.

This is the first of a series of studies by the ASM Advisory Group on Industrial Practices to provide documentary answers to a number of questions relating to activities of the A.S.M. membership. In a Society which, only a few


Metal to be Cut
45% 18% 8% 3% 2% 1% 0
Tool Material Used
4% 18% 17% 13% 9% 4% 0
Type of Operation
25% 26% 14% 6% 2% 1% 0
Quantity of Production
5% 6% 14% 13% 12% 10% 0
Cost
5% 11% 16% 15% 13% 10% 0
Supplier's Engineering Service
3% 2% 7% 9% 12% 18% 1%
Other
2% 1% 1% 1% 1% 1% 5%
1st 2nd 3rd 4th 5th 6th 7th
Factors Influencing Purchases:



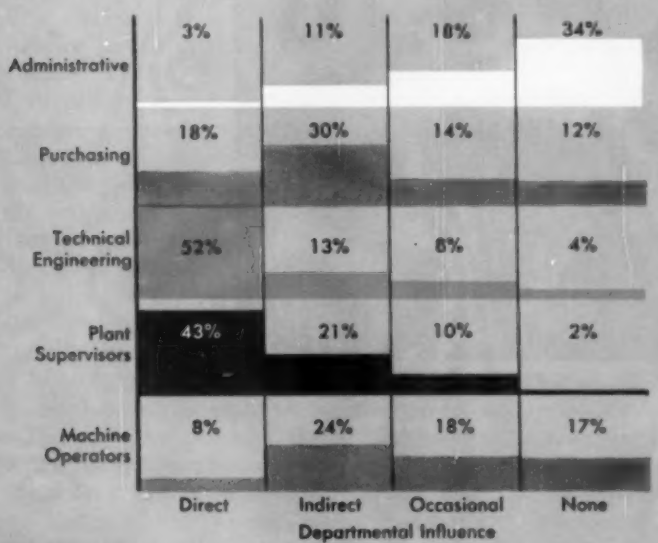
short years ago, was devoted primarily to the heat treatment of metals, there is a need at A.S.M. headquarters for an accurate estimation of broad interests and influences of its 29,000 members. Such data are obviously necessary if present activities are to be properly carried out and future development properly planned.

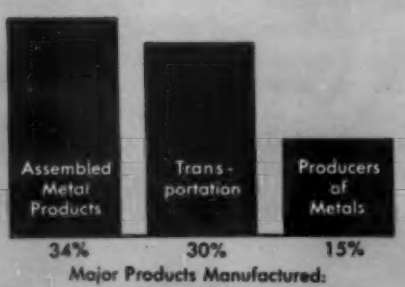
Types of Metals and Tools – Ferrous and nonferrous metals are about evenly divided as metals that are being machined in plants served by A.S.M. members; 78% indicated that ferrous metals are machined while 61% list nonferrous metals. Among the ferrous metals, stainless steels received top rating (24%), while aluminum is tops among the nonferrous metals with 26%. Special metals, such as zirconium, beryllium and titanium, are being machined in a surprisingly large 23% of the plants, with titanium leading the pack (10%).

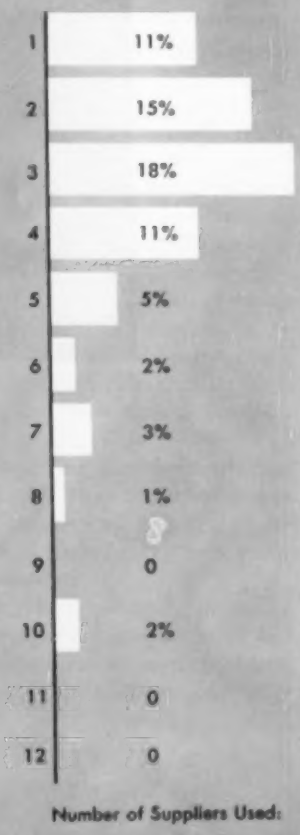
Again, on tool materials there is an almost even split between toolsteels and cemented carbides – 78% and 77% respectively. It is important to note that the relatively new ceramic tooling is being used in 12% of the plants. Evidently ASMembers are with progressive concerns – or to put it another way, ASMembership means progress!

Departmental Influence – Engineering executives and personnel show most influence on the selection and purchase of cutting fluids, 52% having a direct influence and 21% more having indirect or occasional influence. Direct influence is exercised by 43% of the plant supervisors, with purchasing, machine operators and administrative officers following in that order. As might be expected, purchasing shows a strong indirect influence (30%). About 63% of the questionnaires noted that there is a definite trend toward the use of multipurpose fluids; only 21% cited a preference for single-purpose fluids. Many other types are listed, including synthetics, special-purpose, soluble oils, water-type, and oils with additives. Three or more suppliers are used by 42% of the respondents; 11% confine their supplies to one source, and 15% to two.

The 239 men who completed questionnaires represented 239 different plants with an average of 3010 employees. Average monthly volume of cutting fluid used is 2861 gal. If this monthly average were maintained for *all* plants represented by *all* members of the American Society for Metals, the railway tank cars required to supply their demands would form a train 15 miles long.







Biographical Appreciation of an

Lloyd Montgomery Pidgeon

Eminent Living Metallurgist

CHOICE OF THE right man for the right job was never more fortunately made than when, in 1937, Gen. A. G. L. McNaughton, director of the National Research Council of Canada, assigned a project to Lloyd Montgomery Pidgeon. The job was simply to develop a process for the production of magnesium from materials available in Canada.

Practically unlimited deposits of dolomite ore are to be found in Canada, and with this as a source, Dr. Pidgeon developed a simplified process for direct reduction using ferrosilicon as a reducing agent. Not only did the method, by culminating in a distillation cycle, produce ingot of unique purity, but it proved to have a sound industrial and economic basis, and by 1942 a plant of Dominion Magnesium, Ltd., was in production. Five Pidgeon plants were subsequently erected in the United States.

Dr. Pidgeon did not rely on inspiration alone; his process is based on a solid and extensive scientific background and training. Born at Markham, Ont., in 1903, he graduated from the University of Manitoba in 1925, then went to McGill University where he received his M.S. in 1927, and his Ph.D. in 1929. As the Sir William Ramsay Memorial Fellow for Canada, he was next sent to Oxford University in England.

In 1932 he started his professional career as a member of the staff of the National Research Council at Ottawa, where he delved into electrochemical problems. It was here that he received the assignment to develop magnesium, and in 1941 he joined Dominion Magnesium, Ltd., as director of research. In 1943 he was appointed professor and head of the department of metallurgical engineering at the University of Toronto – the position he now holds.

In recognition of his work, Dr. Pidgeon has received many honors. Among the most important are the Order of the British Empire; medal for distinguished scientific work from the Professional Institute of Civil Service of Canada; the Platinum Medal of the Canadian Institute of Mining and Metallurgy, donated by the International Nickel Co. for contributions to extractive metallurgy; the McCharles Prize awarded to any Canadian who invents or discovers a new and improved process for the treatment of Canadian ores and minerals; the Ambrose Monel Medal from Columbia University, for distinguished achievement in mineral technology. He is metallurgical consultant to Atomic Energy of Canada Ltd., and to Dominion Magnesium Ltd. He serves on the board of directors of the latter company, and also of the Foundation of Canada Engineering Corp., Ltd. Dr. Pidgeon is the holder of several patents and the author of numerous scientific publications.

It has been truthfully said that behind almost all successful men is to be found the influence of a gracious and understanding woman, and anyone privileged to know the private life of Dr. Pidgeon will corroborate this. It was in 1928 that Lloyd Pidgeon married Frances Rundle, daughter of Wm. A. Rundle of Winnipeg. They have two children – Ruth, now Mrs. N. B. Bryson, and a boy, Leslie, sixteen, who attends Trinity College School at Port Hope, Ont.

Dr. Pidgeon is a good example of the "do-it-yourself" man. He is equally at home installing plumbing or doing carpentry work, and is interested in English sports cars, particularly their mechanical aspects. Another facet of Lloyd's life is his interest in music. In his student days he played the clarinet, saxophone, and banjo, and today is enjoying his very fine hi-fi records, especially the music of Mozart. He is also a chess devotee.

A few years ago, in the course of his wanderings around Lake Simcoe, not far from his home in Toronto, he came upon a log barn some 100 years or more old. He purchased it and from it superintended the building of an attractive summer cottage, where his more fortunate friends may pass a most delightful weekend.

Dr. Pidgeon has the distinction of not being a golfer or a gardener. He has an aversion to Finnish steam baths such as one of his neighbors has installed, and to certain well-known business magazines read by many busy men as synopses of current events.

As a college professor, he is perhaps admired rather than loved by his students, who respect his mental alacrity and driving energy. Many coming metallurgists of Canada owe their training to this earnest teacher.

Interviewers have the opportunity of seeing their subjects under a rather special light, and in this light Dr. Pidgeon shines as a courteous, alert and kindly Christian gentleman.

HAROLD J. ROAST

Thirty Years in American Metallurgy

*By JOHN J. B. RUTHERFORD**

In retrospect, the state of metallurgical art, science and industry existing in 1926 (when Sauveur gave a "modern" definition of the microconstituents in steel) appears rather elementary in many fields – metallography, materials, manufacturing methods, control. (A2, M general)

I'D LIKE to talk about Albert Sauveur (to whom I was, figuratively, a junior apprentice) and I'd also like to talk about metallurgy, my profession. Maybe a good start would be to contrast the present status of metallography with that existing in 1926, when Sauveur defined the significant constituents in steel as follows:

Austenite is a solid solution of carbon, probably in the form of carbide Fe_3C in gamma iron.

Troostite is a solid solution of carbon, probably in the form of carbide Fe_3C in beta iron.

Austenite always transforms into troostite regardless of the temperature at which transformation takes place.

Martensite is the aggregate of austenite and troostite necessarily resulting from the gradual transformation of austenite into troostite.

Troostite of eutectoid composition transforms into *sorbite*.

Pearlite results from the coagulation into plates of the constituents in sorbite.

He postulated that austenite transformed on cooling through the stages of troostite to sorbite to pearlite. Austenite retained on quenching then transformed on tempering through the same stages: first to troostite, then sorbite and finally pearlite.

The ideas of that period look strange in light of our information today. There were endless debates about whether the carbon in austenite was in solution as iron carbide or as atomic carbon. (Most of the information on diffusion in the solid state has been obtained since that time.) Then there were discussions on the reality of the beta phase of iron and its justification by the phase rule. (How many of today's students are familiar with beta iron and with recalescence? How many have seen a demonstration of steel momentarily heating up while it was being cooled in air?) The problem of obtaining reproducible results with existing laboratory equipment was considerable; the Bureau of Standards was just establishing temperature constants and methods of chemical analysis.

Looking back, it is easy to see that metallography was then in a state of transition. The publications of that period make metallurgists look like Greek philosophers, with frequent pleas for more experimental evidence to substantiate the numerous theories being proposed. Dartrey

* Chief Metallurgist, Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. This article is a slight condensation of the Sauveur Lecture presented before the Philadelphia Chapter, ASM, 1957.

"Martensite and Troostite" in Quenched Steel. 1000 ×. Representative of highest quality work with light microscope in 1930's.

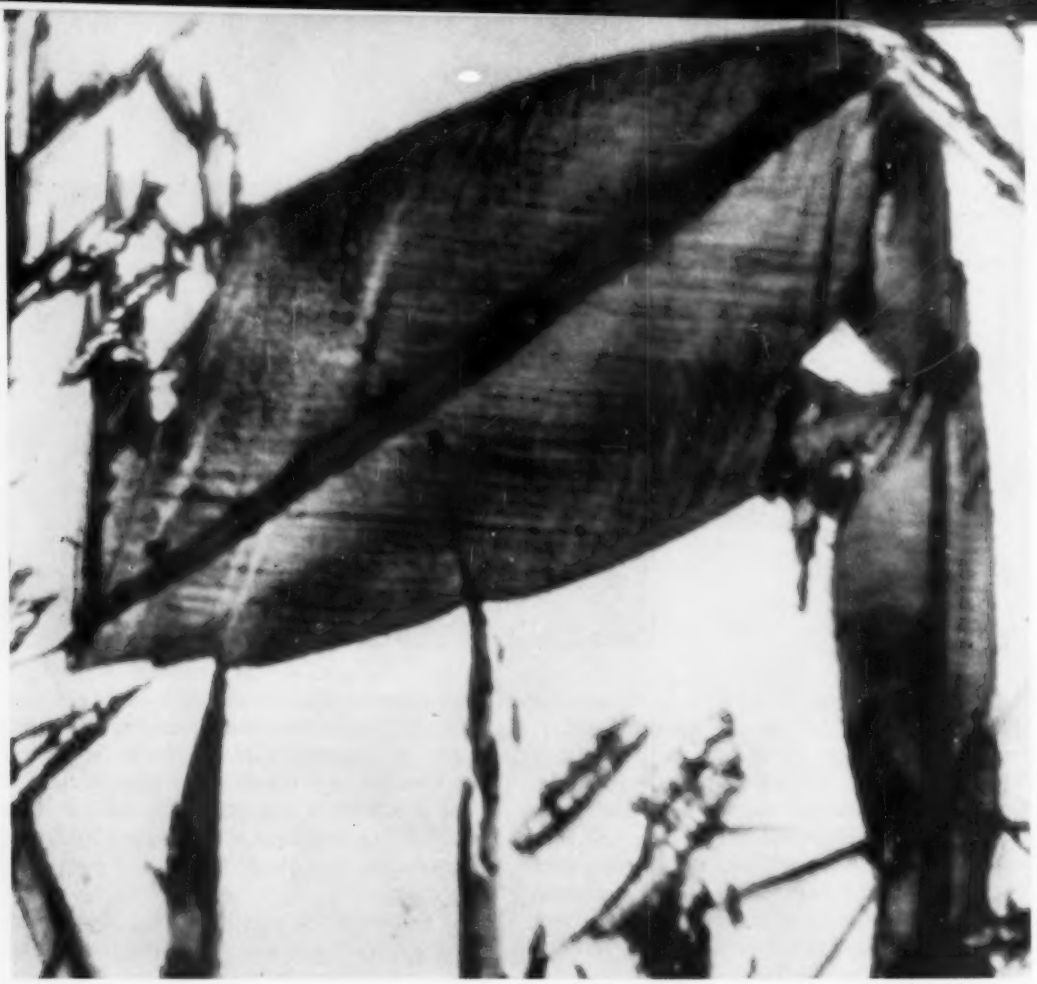
Lewis, who, with me, was working with the late A. V. de Forest at American Chain & Cable Co., write in the *Journal* of the Iron and Steel Institute in 1929 that "an 0.8% carbon steel may be quenched in a molten salt bath at 450° F. to comparatively stable austenite, which will convert to martensite on cooling. The cooling may be slow or rapid, with practically no influence on the final hardness of Rockwell C-59." Here then, is a description of martempering and the M_s point. He also noted that at 600° F. austenite transformed to a martensitic-appearing structure and commented: "Apparently the austenite decomposed into a needle-like crystallization at temperatures above 450° F. as well as below this temperature." Here, unrecognized, were bainitic structures. J. M. Robertson, in the same *Journal*, published photomicrographs of steel quenched from austenite under various conditions, in order to refute the prevailing theory that the transformation of austenite to pearlite involved as intermediate stages, martensite, troostite and sorbite. Robertson was almost at a break-through of the knowledge barrier.

In 1929, I went to work for U. S. Steel Corp. at the Kearny Research Laboratory and promptly was assigned to work which contributed to the justly famous paper by Davenport and Bain on "Transformation of Austenite at Constant Subcritical Temperatures," published in the *Transactions* of the American Institute of Mining and Metallurgical Engineers in 1930. They believed that the microstructures obtained on continuous cooling formed in increments at a sequence of temperature levels, and could be interpreted by knowing what the structures were after direct transformation of austenite at a single temperature. The latter they identified as pro-eutectoid ferrite, pro-eutectoid carbide, pearlite, fine pearlite, troostite and martensite. Identification of some constituents was admittedly difficult, even with Vilella's technique of etching a whole series of specimens in a single holder and comparing fine differences.

At that time, the microscope was the primary tool for searching into metallic structure. However, new techniques such as X-ray diffraction, were appearing.

Bain, Westgren and others had just established the crystallographic architecture of iron in its various allotropic forms; the arrangements of atoms in space. In 1926 we were trying to capture an atomistic explanation of the changes which occurred during heat treatment. While there was considerable divergence of opinion as to how carbon fitted into the lattice, there was general agreement that in order to produce martensite, austenite must undergo allotropic transformation below about 575° F. In support of his views Sauveur leaned quite heavily on the excellent photomicrographs of F. F. Lucas who obtained magnifications of 3000 times with remarkable resolution.

Age hardening had been studied during World War I by Merica, Waltenburg, Scott and Freeman to find out how the Germans were able to "harden" aluminum. By 1924 Jeffries and Archer in their "Science of Metals" had presented their "slip interference" theory of hardening which postulated the formation of "knots" of atoms, in dimensions too small to be resolved by microscopy. At the same time, statistical distribution



Individual Martensite Needles. From the pioneering work at high magnification by Francis F. Lucas. 5250 ×

did not permit identification of these atom clusters by X-rays. So the reliable and conventional probe – the microscope – was too coarse while the exotic new tool – X-rays – was too fine to establish the evidence for proof of the slip interference theory. The microscope could only serve to locate constituents from over-aging, long after peak hardness had been obtained.

To compound the difficulties was the fact that magnetic iron became nonmagnetic and vice versa at a fixed temperature, and apparently this profound difference in properties did not depend on any atomic rearrangement, any phase changes.

All this scientific confusion occurred at a time when the metallurgical industry was enjoying a high degree of stability. Industry, in fact, had made remarkable progress entirely on an empirical basis. Wire of eutectoid composition was processed continuously by heating above the critical temperature and then quenching in molten lead to obtain an excellent combination of mechanical properties, a process long known as "patenting" but very like "isothermal transformation". Papers were written on the subject of normalizing or patenting high-quality bridge wire and cable. They mainly described practices developed by workmen in the shop.

Thirty Years Later

Metallography – While metallographers at the present time have a much clearer idea of the main constituents in steel (and other alloys), their mode of occurrence as affected by composition and past history is being studied with great diligence by men like Troiano. Metallographic studies have revealed cracks on shear planes in martensite needles, demonstrating the high internal stress formerly postulated as a cause of hardness. This has contributed to the theories of dislocation and lattice imperfections. Metallurgists once paid much attention to best methods for polishing and etching metallographic specimens. Today, this work is largely relegated to the technician, so the metallurgist is available for

Modern Electron Micrograph of Martensite. (Courtesy Fundamental Research Laboratory, U.S. Steel Corp.) 30,000 ×

more discretionary problems. Unfortunately, we must lose some of the intimacy of our work as the price for delegating these tasks to others.

There has been little change in the optical system of metallurgical microscopes since Sauveur's time, but great advances have been made in illumination and the mechanics of the stage and focussing. The last 20 years has seen the advance from the light microscope to the electron microscope permitting equal resolution at 100-fold higher magnifications. The neutron microscope promises to reveal still more details of structure.*

The pioneers, naturally, made many discoveries because they were in virgin territory. Now the boundaries of the field have been plotted, the remaining work is to subdivide the territory. The main industrial application of the metallurgical microscope today is rating grain size and cleanliness – but let no one misjudge the importance of this work.

The Metallurgist – Now look at some of the topics which have occupied the attention of metallurgists during the past 30 years, time including the depression, World War II and the Korea "incident," all of which have left their impression on our activities. The scope of metallurgists' activities has grown tremendously and helps to account for the present shortage of engineers. The growth of membership in the A.S.M. is probably a good criterion of the spread of interest in this field – 4600 in 1927, 29,350 in 1958. In fact the name was changed in 1933 from the American Society for Steel Treating, since this title was too restrictive, to American Society for Metals.

Material – The quality and characteristics of steel have changed in this same span of 30 years. Even the historic cast iron is being converted to nodular iron. The "ideal" steel in the 1920's was an unalloyed eutectoid composition – rails, high-strength wire and simple cutting tools. The

* Modern metallographic methods were examined in some detail during a meeting at the ⊕ Convention in Chicago last November.

manufacture of killed steel and the controlled deoxidation practice were introduced only about 25 years ago. Shepherd wrote on hardenability in 1930 and helped take the mystery out of "body" of toolsteel; grain size came to be recognized for its influence on heat treating and mechanical properties.

The biggest tonnage production of steel is still rimmed or open-top steel, but the tonnage of quality alloy and electric furnace steels now exceeds the total tonnage of Sauveur's time. Between 1900 and 1910 numerous investigators searched for better heat resisting steels for pyrometers, gun liners and gasoline engines. This led to the manufacture of numerous chromium steels. A chance observation, apparently repeated simultaneously, that these metallographic specimens did not rust in a laboratory atmosphere, marked these alloys as "rustless" or "stainless" and during the 1920's they were introduced into the food and chemical industries and into hospital equipment. By 1930 development of the austenitic nickel-chromium stainless steel almost came to a complete stop because of an epidemic of failures by intergranular corrosion. The microscope recognized the culprit, and a remedy was administered which gave a new lease of life to the well known 18-8 steels.

The "critical mass" for heat treating was common topic for discussion 30 years ago. The recognition of hardenability and its association with transformation rates brought about a systematization of alloy steels, known first as the S.A.E. steels and then as the A.I.S.I. Shortage of strategic elements during World War II modified these to N.E. or National Emergency steels, many of which depended on a small addition of boron as a hardening element. The concept of "H-band steels" departs from the conventional practice of selecting steels by chemical analyses, and emphasizes the fact that it is *performance* in fabrication and service which counts.

A glance at the 1948 edition of the ASM Metals Handbook illustrates the importance of cataloging the properties of nonferrous metals. An enormous amount of metallurgical time was spent during the 1940's on uranium, thorium, zirconium and beryllium alloys – information which is just now becoming important to the atomic power industry. Everyone is familiar with the growth in knowledge and application of titanium since 1950. Its production in tonnage by steel companies required vacuum melting equipment or consumable electrode melting practice – both of which are now applied in making special quality steels. Some of our progressive research laboratories combine studies of metals and ceramics because of the merging field of common interest.

Heat Treating – Sauveur's interest in heat treating centered around the transformation of austenite to martensite, which he believed to be the primary reaction. He continuously sought an explanation of the hardness of martensite. He saw little reason to credit "aging" as a contributor to hardness, in spite of what was demonstrably true of duralumin and other high-strength aluminum alloys. The studies on isothermal transformation published by Davenport and Bain in 1930 went far to clarify these hardening reactions in steel and resulted in new concepts of heat treatment, such as martempering and austempering. The excellent work of Shepherd on fracture grain size and hardenability of toolsteel helped to put many of the recent theories into practical application. Control of deoxidation practice in steelmaking, and automatic temperature controllers for carburizing, met the automotive industry's requirements for dependable bearings and gear trains by mass production. This period also saw the application of controlled atmospheres in commercial heat treating. The microscope was again the guiding tool.

The more recent developments in heat treating have dealt with the practical aspects. Automation has taken over wherever the operation is repetitive. The growth of consumer appliances requires multitudes of small pieces with exacting requirements for surface hardness, toughness, springiness, and so on. The tremendous expansion in transportation and moving parts has led to an even greater expansion in the antifriction bearing industry. Heat treatment in these industries is controlled by statistical sampling plans. To cut costs, steels are being heated at rates considered impossible 30 years ago, and in such a manner that the product is reproducible within very close limits.

In many of the modern applications of heat treating, the conventional mechanical properties such as tensile strength are of secondary importance. For example, large quantities of 52100 and 8620 steels are heat treated so as to obtain desirable and reproducible machinability, and subsequently re-heat treated to an entirely different set of properties for ultimate service. Stainless steels are heat treated to enhance their corrosion resisting properties. Steels used at elevated temperatures are heat treated for best creep resistance – a property which cannot be predicted from ordinary tensile tests. Weld-

ments are heat treated for stress relief. Many of the newer metals exhibit a martensitic reaction and would have delighted Sauveur.

The production pressure of World War II brought about new concepts of statistical quality control. In the production of shells, steel was raised to temperature at phenomenal rates, shaped and then cooled so as to incorporate a heat treatment during fabrication. Leaner alloys were often used, although occasionally an old standby, such as 52100 steel for ball bearings, defied modification. One major contribution of the war period was the recognition of boron as an alloying element.

Corrosion – In 1930, Huey published a description of the corrosion test used by Du Pont to qualify material for nitric acid plant. About 1935, La Que opened the International Nickel Co. corrosion test station at Kure Beach. New, long and large oil and gas pipelines placed great emphasis on corrosion costs and protection of carbon steel. Many recent problems in corrosion would surely be strange to Sauveur, such as pressurized water systems of nuclear energy (where the "pure," demineralized water seems to raise more problems than river water). As if aqueous electrolytes do not present enough trouble, we have liquid metal reactors which bring back some of the problems encountered with mercury boilers 25 years ago – back in Sauveur's time.

High Temperatures – In 1924 the American Society for Testing Materials held a symposium on the Effect of Temperature on the Properties of Metals, which was the first collection of data on creep testing and creep resistance of metals. The Campbell lecture by Sauveur in 1930 was entitled "Steel at Elevated Temperatures" and demonstrated the reduction in strength of steel at elevated temperatures, until the transformation temperature was reached, when austenite became stronger than ferrite at a lower temperature. Sauveur's technique of torsion testing became a simple test to measure high-temperature forgeability – for example to judge suitability of steel in the manufacture of seamless tubing. While World War II saw a suspension of the regular creep test program and an all-out effort to develop "superalloys" for the new jet engines, the A.S.M.E. Boiler Code Committee has established design data for the common constructional steels. The original test data were based on uniaxial loading of steady state stress at constant temperature, but service failures occur which cannot be correlated with this information, and the last few years have seen many studies with variations in test procedure, such as cyclic loading, cyclic temperatures and the effect of different atmospheres. All these problems pale in contrast with those to be met in supersonic aircraft and long-range missiles, both in heat resistant combustion systems and protective skins or sheaths.

Quality Control – Testing for control of uniform properties, in conformance with specifications, was in a sad state 30 years ago, when judged by today's standards. Where the highest performance was desired, an occasional sample was submitted for tensile test. This practice started with structural components involving human safety, such as bridges. The aircraft industry at one time required that all critical components be proof tested by stressing above the maximum design stress. In the toolsteel industry, an occasional sample was heat treated and fractured to demonstrate suitability; if it could not be "touched" with a file it was hard enough.

A. V. de Forest, who studied metallography at Columbia early in the century, was intrigued with the measurement of magnetic properties as a nondestructive test for uniform heat treatment. This led, about 1930, to the Magnaflux method of testing. He also developed stress-sensitive lacquers to expand this general method.

World War II required material in such tremendous quantities that it was impossible to test each unit. It was necessary to approach this problem by radically new methods. Statistical sampling plans already highly developed by Bell Telephone scientists, were brought into practice. The Society for Nondestructive Testing has been formed by those who prefer to test every article and still have the article available. Among the latest methods of testing are those involving ultrasonics and eddy currents, with electronic circuitry which would have delighted de Forest. The present expansion in nuclear power requires so much testing for quality control that it has become a significant part of the total cost.

The Future

The field of metallurgy has broadened and, as the old saying goes, we know less and less about more and more. I hope and believe this situation is more apparent than real.

There can be no conclusion to a live topic. The master metallurgists are thinning out and are being replaced by teachers, administrators and technicians. Maybe in another 30 years, someone else will pick up the thread of this story and weave it into a bolder, sharper pattern.

Correspondence . . .

Batteries for Sputniks

WASHINGTON, D.C.

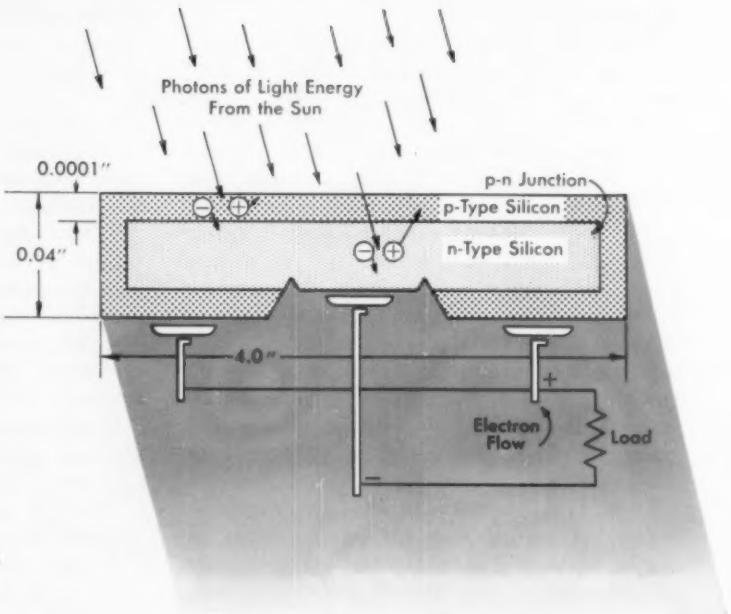
It appears that "solar batteries" made of p-type and n-type silicon can provide power for satellite instrumentation. This matter has been tested by attaching glass-encased solar cells to the skin of a rocket launched this spring at White Sands Proving Grounds in New Mexico. This rocket reached an altitude of 190 miles and, until the rocket's radio ceased functioning on re-entering dense atmosphere, the batteries functioned perfectly. Their electrical output varied only slightly, depending on the varying exposure to direct or reflected sunlight, and was not affected by the high temperatures of skin friction in atmosphere at a mile a second, or any collisions with meteor dust.

In an earth satellite such cells would generate electricity about 60% of the time (the remainder being that portion of the orbit in the shade of the earth), and during that time they would not only furnish power for the instruments and radio but also charge small nickel-cadmium batteries which would take over during the "night-time".

The nature of the cells was described in *Bell Laboratories Record* for July 1955, under the title "The Bell Solar Battery".

C. F. REILLY, Major G.S.
Office of Chief of Information
Department of the Army

EDITOR'S NOTE – The principle of the Bell solar battery is shown in the sketch. When light strikes a semiconductor an electron (negative particle of electricity) is often dislodged from its normal position or circuit, leaving a positively charged "hole" or vacancy. Both electron and hole will then be available for the conduction of electricity – if they can be prevented from recombining and thus neutralizing each other. The p-n junction provides a built-in electric field that pulls the electrons into the n or negative side of the junction and the holes into the p or positive side before many of them recombine.



Principle of the Solar Battery

The solar cell is thus simply a very large p-n junction oriented to face the sun, and the top layer is made very thin so that as many as possible of the effective photons may penetrate to the vicinity of the junction.

With silicon, the effective parts of solar energy are absorbed in the outer 0.001-in. layer, and to be collected, the electron-hole pairs must be produced within about 0.0001 in. of the junction. In addition to these fine tolerances, the surface must have a high conductivity. The next question was, "How can this be produced?"

One method of forming the p-layer is to heat a plate of n-type silicon in a gas containing boron. The boron diffuses into the silicon to a depth determined by time and temperature. Right at the surface, the silicon is very heavily "doped" with boron. Further into the crystal the concentration decreases until, at about 0.0001 in. it gets so low that the n-type arsenic-doped silicon of the crystal predominates. This change in conductivity type defines the position of the junction. The p-layer is then removed from a portion at the bottom surface and contact is made to the body of the crystal. Contact to the p-layer then com-

familiar names ...in a new combination

A new name in metals—American Metal Climax, Inc.—arises from the merger of two well-known companies, The American Metal Company, Ltd. and Climax Molybdenum Company.

American Metal Climax, Inc. now offers expanded facilities and services. Its activities include mining, smelting, refining, marketing, exploration and research. Its products are molybdenum in all forms, potash, copper, lead, zinc, uranium, vanadium, tungsten, tin, solder, metal powders, precious and rare metals, selenium, germanium, tellurium, cadmium, cobalt, bismuth, arsenic, oil and gas, and others. Its interests circle the globe; principal business activities are in North America, Western Europe, and Africa.

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61 Broadway, New York 6, New York

Climax Molybdenum Company—a Division
500 Fifth Avenue, New York 36, New York

Principal Subsidiaries of American Metal Climax, Inc.

AMERICAN CLIMAX PETROLEUM CORPORATION
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BLACKWELL ZINC COMPANY, INC.
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CÍA. MINERA DE PEÑOLES, S.A.
Monterrey, Mexico

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HEATH STEELE MINES LIMITED
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RHODESIAN SELECTION TRUST LIMITED
Salisbury, Southern Rhodesia

SOUTHWEST POTASH CORPORATION
Carlsbad, New Mexico

UNITED STATES METALS REFINING COMPANY
Carteret, New Jersey

PURITY plays a part in SANDVIK Spring Steel's Super-Performance

Basic purity has a lot to do with Sandvik's ability to deliver top performance in so many difficult spring steel applications. This purity begins with the purest iron ore—obtained from Sandvik's own mines.

Step by step in the production of the quality strip steel, close control is held on the product. Only the purest materials, such as sulphur-free charcoal and sponge iron are used in the furnaces. The only return scrap used is from the Sandvik plant itself.

Sandvik supplies cold rolled specialty strip steels —

- In special analyses for specific applications
- Precision-rolled thicknesses to fit your requirements
- In straight carbon and alloy grades
- Annealed, unannealed or hardened and tempered — scaleless or polished bright, yellow or blue
- With square, round or dressed edges

Sandvik stocks a wide variety of qualities and sizes. In addition Sandvik has Rolling, Slitting, Edge-Filing and Hardening and Tempering facilities.

Write for the new Sandvik brochure and stock lists.

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WORKS: Sandviken and Hallefors, Sweden

Sandvik Quality Steels

55-111

Solar Battery . . .

pletes the electrical arrangements.

Since the announcement of the first experimental device (April, 1954) the efficiency of the cells has been improved. The best of the original cells had an efficiency of about 6%. The efficiency of the newer units has been raised consistently to around 8%, and some cells have converted as much as 11% of the energy they receive from the sun directly into electrical power.

In one of the first demonstrations, a solar battery was used to power a motor turning a small disk, and this disk has been spinning continuously under ordinary indoor lighting for a whole year. A solar battery, consisting of five cells connected in series with a total area of about 10 sq. cm. is charging a 1.35-volt storage battery. On a clear day the charging current averages about 25 milli-amp. from 7 a.m. to 5 p.m.

Brittleness in High-Manganese Stainless

SCHENECTADY, N.Y.

There has been much interest recently in the high-manganese, high-nitrogen austenitic steels. We have checked the reported creep-rupture strength and ductility, but we uncovered some disconcerting data on notched impact properties.

Two alloys of this class were under test. One contained 2% Mo and the other 6% Mo. Each of these alloys was heat treated in two ways: (*a*) 1950° F. for 4 hr. and slow cooled, and (*b*) 2100° F. for 4 hr. and water quenched. V-notch Charpy specimens were machined from the heat treated stock and tested with these results:

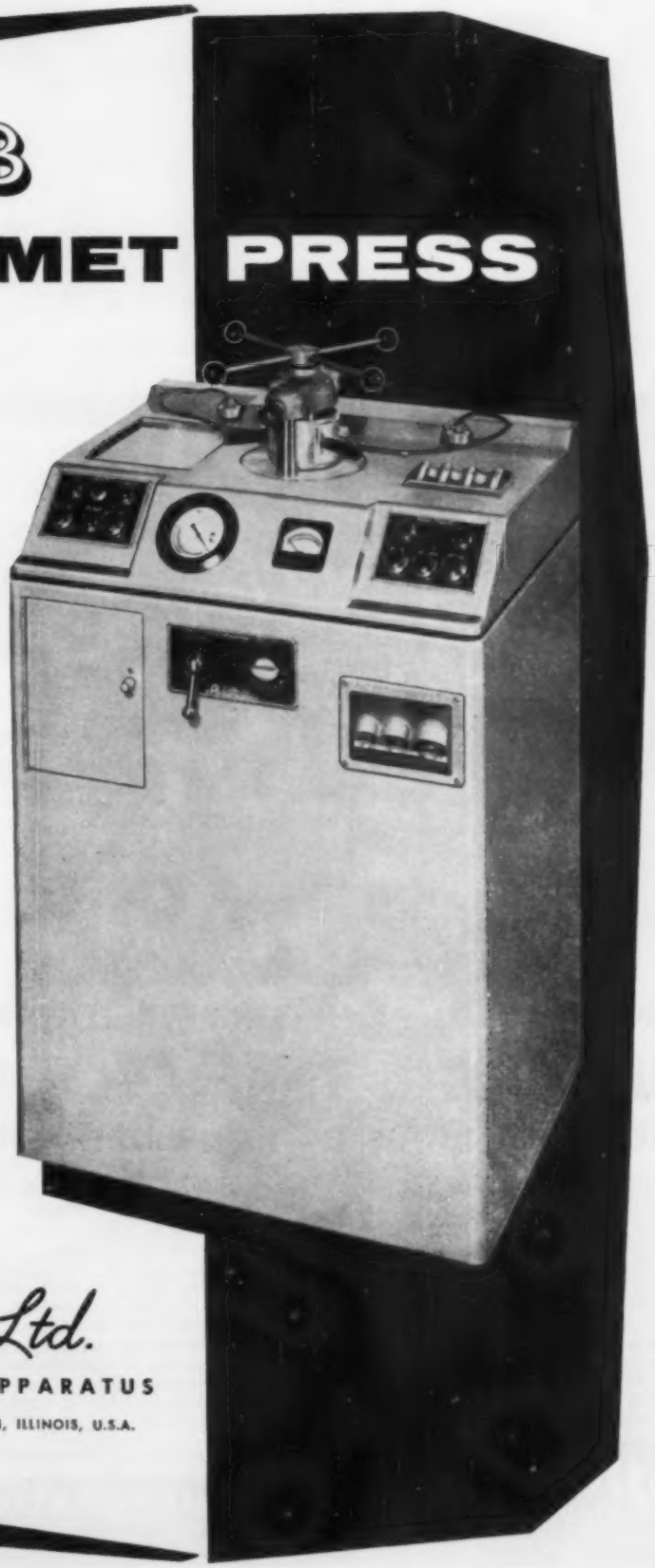
The impact strength of the alloy with 2% Mo was 43 ft-lb. after slow cooling – heat treatment (*a*) – and 59 ft-lb. after water quenching – heat treatment (*b*). The impact strength of the 6% Mo alloy was 57 ft-lb. after heat treatment (*a*) and 114 ft-lb. after heat treatment (*b*). Unfortunately this satisfactory toughness was lost after aging. When kept 1000 hr. at 1200, 1300, 1400, 1500 and 1600° F., the impact energy absorbed dropped to 0.5 to 2.5 ft-lb. for all specimens!

In an attempt to find the cause of

THE NEW

POWERMET PRESS

FOR THE MOST RAPID MOUNTING OF METALLURGICAL SAMPLES



- PUSH BUTTON CONTROLLED
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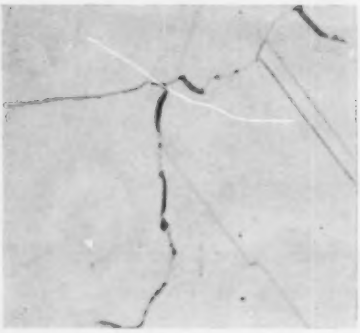
Buehler Ltd.

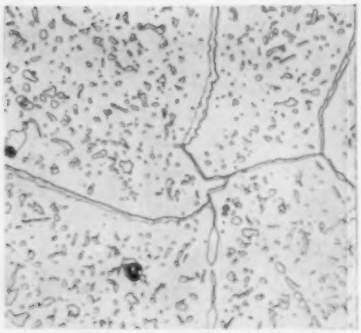
METALLURGICAL APPARATUS

2120 GREENWOOD ST., EVANSTON, ILLINOIS, U.S.A.

Brittleness . . .

this embrittlement we examined the minor phases present in the 6% Mo alloy. The aged impact specimens were electrolytically digested and the minor phases were examined by X-ray diffraction. The precipitates were found to be chromium nitride (Cr_2N) and a Laves phase based on $MoFe_2$. The presence of the nitride was detectable after aging at 1200° F. and above, while that of the Laves phase was clear only when the specimen was aged above 1300° F. Both constituents were best crystallized at 1600° F. Photomicrographs of solution treated and overaged specimens are shown above.





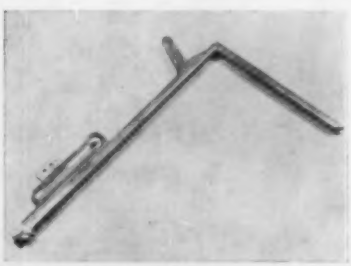
Microstructure of High-Manganese, High-Nitrogen Austenitic Steel Containing 6% Mo. Etchant: 92% HCl, 5% H_2SO_4, 3% HNO_3. 1000 ×. Left – solution treated (tough); right – aged 1000 hr. at 1600° F. (brittle)

This information is passed along in the hope that a solution for the problem described may be suggested by some reader of *Metal Progress*.

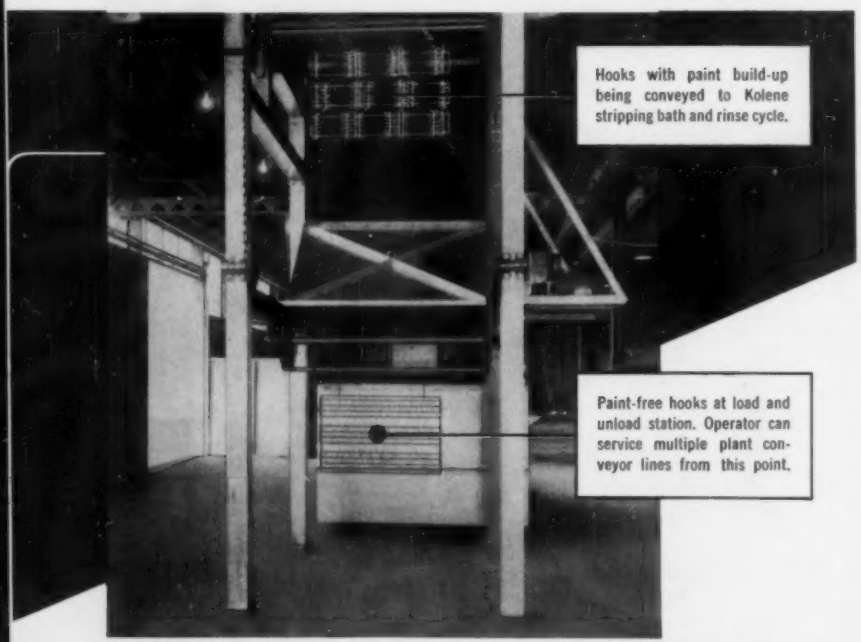
H. J. Beattie, Jr.
General Electric Research Laboratory

Spindly Die Casting

One answer to the contest between castings and brazed sheet assemblies is shown in the view of a 24½ × 13-in. zinc die casting serving as a window frame for a "hard top" automobile. It is die cast in a highly polished, single-cavity die having a long slide that acts as the core to form the slot in which the glass rests. The die casting is then chromium plated. Formerly this component was assembled of welded rolled sections and steel stampings.



Die Cast Window Frame, Legs 24½ and 13 In. Long


Hooks with paint build-up being conveyed to Kolene stripping bath and rinse cycle.
Paint-free hooks at load and unload station. Operator can service multiple plant conveyor lines from this point.

CONVEYORIZED PAINT STRIPPER FEATURES

AUTOMATIC TIME CYCLING

AND CONTINUOUS 24 HOUR OPERATION

Now it is possible to strip paint from hooks and racks *when required, and without costly tie-up of the paint line.* Leading appliance and automotive parts manufacturers are doing it with the *Kolene molten salt bath paint stripping process in an automatic conveyorized unit.*

Advantages are many: The process is both economical and extremely practical. Inventory of hooks and racks can be reduced to a minimum because it is not necessary to carry a backlog of fixtures while stripping. Hook repair costs are minimized by eliminating old-fashioned handling and stripping methods.

Human factor is eliminated by automatic, adjustable time cycling.

One man can operate . . . loading and unloading racks from *multiple conveyor lines* . . . while the fixtures are being stripped clean in one to three minutes.

24-hour continuous stripping can be maintained because of Kolene's exclusive maintenance features. Sludge can easily be removed *without* costly shut-down time. *Write now for details!*

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LEADER IN SALTBATH CLEANING

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XXV

This is the twenty-fifth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Thermal Stress-Relieving of Alloy Steels

In the production of alloy steel bars and parts made of alloy steel, stresses are sometimes set up, and these stresses must be relieved before optimum results can be expected. Two general types of stress-relieving are practiced—thermal and mechanical. In this discussion we shall consider only the former.

There are several important reasons for thermal stress-relieving. Among these are the following:

(1) The first and most fundamental purpose is to reduce residual stresses that might prove harmful in actual service. In the production of quenched and tempered alloy steel bars, machine-straightening is necessary. This induces residual stresses in varying degrees. Bars are usually stress-relieved after the straightening operation. When the bars are subjected to later processing that sets up additional stresses, subsequent stress-relieving may be necessary.

(2) A second major purpose of thermal stress-relieving is to improve the dimensional stability of parts requiring close tolerances. For example, in rough-machining, residual stresses are sometimes introduced, and these should be relieved if dimensional stability is to be assured during the finish-machining.

(3) Thermal stress-relieving is also recommended as a means of restoring mechanical properties (especially ductility) after certain types of cold-working. Moreover, it is required by the "safe-welding" grades of alloy steels after a welding operation has been completed.

Alloy bars are commonly stress-relieved in furnaces. Temperatures under the transformation range are employed, and they are usually in the area from 850 deg to 1200 deg F. The amount of time required in the furnace will vary, being influenced by grade of steel, magnitude of residual stresses caused by prior processing, and mass effect of steel being heated. After the bars have been removed from the furnace, they are allowed to cool in still air to room temperature.

In the case of quenched and tempered alloy bars, the stress-relieving temperature should be about 100 deg F less than the tempering temperature. Should the stress-relieving temperature exceed the tempering temperature, the mechanical properties will be altered.

Items other than bars (parts, for example) can be wholly or selectively stress-relieved. If the furnace method is used, the entire piece is of course subjected to the heat; selective relieving is impossible. However, if a liquid salt bath or induction heating is used, the piece can be given overall relief or selective relief, whichever is desired.

Detailed information about stress-relieving is available at all times through Bethlehem's technical staff. Feel free to consult with our metallurgists, who will cooperate fully without cost or obligation on your part. And remember that Bethlehem can furnish the entire range of AISI standard alloy steels, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements from No. I through No. XX, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 20 subjects in the series are now available in a handy 36-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

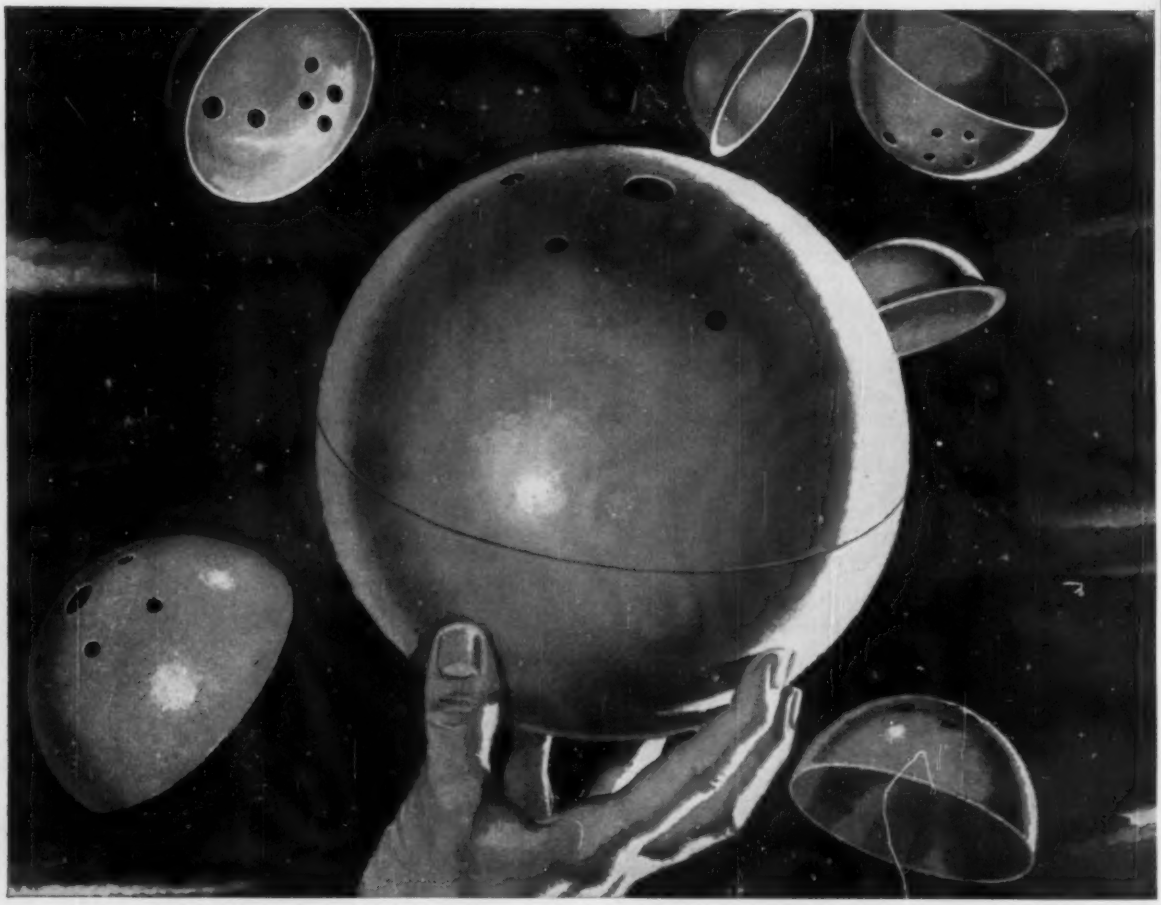
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Problem-Solving Products from Republic

SAVE WEIGHT, FIGHT CORROSION, ADD STRENGTH AND TOUGHNESS



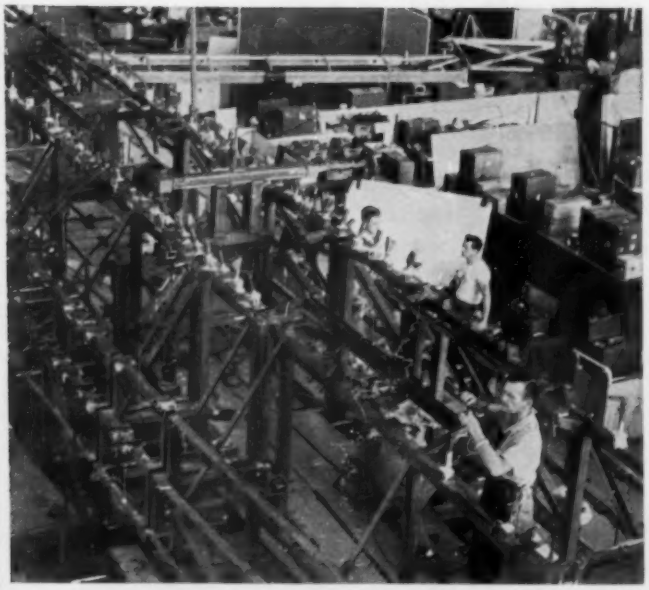
TITANIUM HEMISPHERES ARE STRONG, LIGHTWEIGHT, DEFY CORROSION BELOW −150°C. They are used in highly specialized aeronautical applications calling for high strength, light weight, and resistance to the severe corrosive action of liquefied gases at severe sub-zero temperatures.

Alloy Products Corporation, Waukesha, Wisconsin, utilizes three major advantages of commercially pure Republic Titanium, Type RS-70, in meeting these requirements:

1. Titanium reduces weight without sacrifice of strength or safety. In fact, titanium offers the highest strength-to-weight ratio of construction materials.
2. This exceptionally high-strength property enables this product to withstand burst pressures in excess of 2,000 lbs. psi.
3. Titanium's extremely high corrosion-resistant properties defy the corrosive action to which the units are constantly exposed.

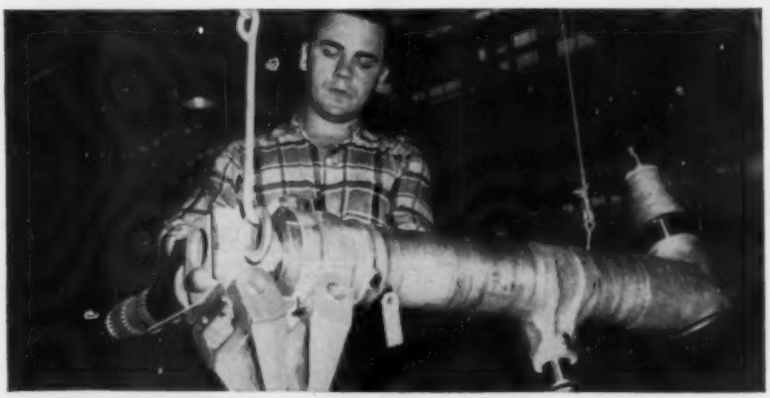
The entire fabricating operation is performed without difficulty and with little change in procedure as compared to other materials. Fabricating steps include drawing, trimming, piercing, extruding, and welding.

Does this application of Republic Titanium generate an idea for your product that needs to be strong, lightweight and corrosion-resistant? Republic Metallurgists are ready to help you apply titanium's advantages now. This service is confidential and without obligation. Mail coupon today for more information.



STRENGTH AND SAFETY IN MISSILE jig and fixture assemblies is provided by 4" x 4" square carbon steel mechanical tubing. It is used because of its greater strength-to-weight ratio in structural applications. Elimination of accident-causing sharp edges adds to the safety margin. Republic Steel and Tubes Engineers will help you design ELECTRUNITE Mechanical Tubing into your product to speed production, cut costs, save weight, improve product performance. Mail coupon.

TOUGHNESS, HIGH STRENGTH-TO-WEIGHT RATIO, resistance to heat and corrosion are advantages of ENDURO Stainless Steel designed into both structural and operating parts of supersonic Convair F-102A. ENDURO is made for flight in both military and civilian aircraft. Its outstanding combination of properties offers almost unlimited freedom in design and application. Republic will help you apply it to best advantage. Write us.



MAXIMUM RESISTANCE TO FATIGUE, strength and toughness are provided by Republic Alloy Steel in landing-gear struts of North American's F-100. The struts are made by Bendix Aviation Corporation. Bendix and Republic metallurgists, working closely with North American engineers, developed a new grade of alloy steel to meet exacting requirements of the strut's inner and outer cylinders. It has a strength range of 220,000—240,000 psi and maintains this great strength at wide temperature extremes. Republic Alloy Metallurgists are available to help with your projects.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. C-5123
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Have a metallurgist call. ☐ Titanium ☐ Stainless ☐ Alloy

Send more information on:

☐ Titanium ☐ Stainless Steel
☐ Mechanical Tubing ☐ Alloy Steel

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Company _____

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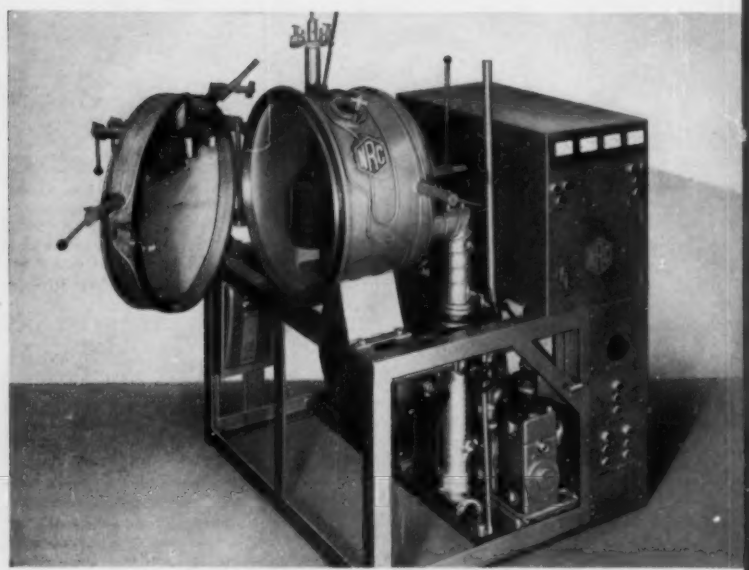
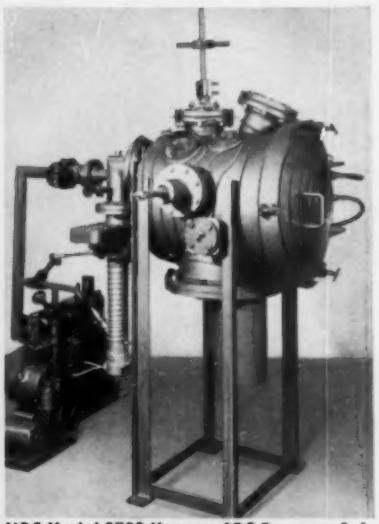
Get Started Easily In Vacuum Metallurgy

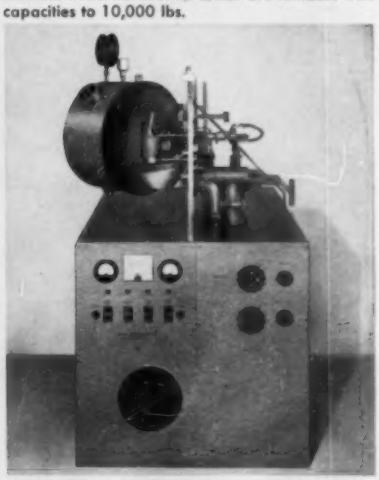
NRC experience and standard ARC, INDUCTION and RESISTANCE furnaces can remove the mystery from vacuum metallurgy



NRC Model 2551 Vacuum INDUCTION Furnace. Packaged facility for melting, purifying, alloying, casting and heat treating. Capacity 12 lbs. Other standard and special induction furnaces with capacities up to 5000 lbs.



NRC Model 2703 Vacuum ARC Furnace. Safe and versatile unit for consumable or nonconsumable electrode melting into cold mold or skull (consumable head not shown). Other arc furnaces with capacities to 10,000 lbs.



NRC Model 2904-B Vacuum RESISTANCE Furnace. Over 100 now in use for melting, purifying, alloying, casting, sintering, brazing, annealing, and heat treating. Capacity 2-8 lbs. Temperature above 2000°C. Pressures to 10^{-5} mm Hg. Other standard resistance bell, muffle, and pit furnaces with hot zones to 54" dia. by 12'.

If you're considering vacuum metallurgy as part of your product improvement or quality control program, you don't have to start from scratch. You can get a head-start by drawing on the experience NRC has gained from building and operating more high vacuum furnaces than any other organization in the world. You can easily find out

If vacuum metallurgy can help you as it has others.
Whether you really need to run your own development program.
What type of furnace would be most suitable for your program.
How to avoid the expensive pitfalls which have so often trapped beginners.

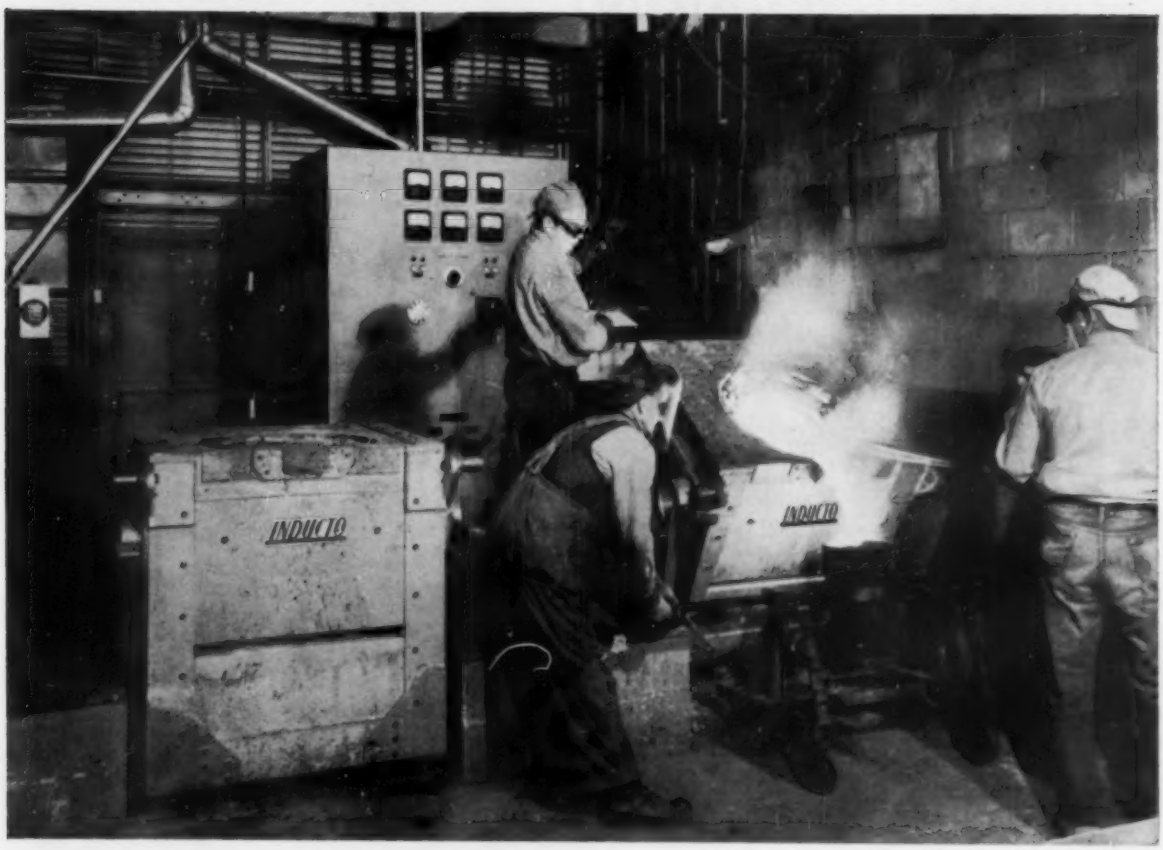
Then, if you decide to run your own development program, you'll find you can get started easily, economically and quickly with a standard NRC furnace, such as those shown here. You won't need a vacuum expert to run it either. NRC furnaces are designed for simplicity, and our engineers will teach you up-to-date operating techniques. This is the way for you to get useful results sooner, with a minimum investment in equipment, time, and operating costs.

Get started easily by writing for more information today.

NRC
NRC
EQUIPMENT
CORPORATION

DEPT. IP, CHARLEMONT ST., NEWTON 61, MASS.
A Subsidiary of National Research Corporation

another Inducto installation...



Waukesha Improves Stainless Castings With INDUCTO Furnaces

Waukesha Foundry Company, Waukesha, Wisconsin, is a major producer of stainless steel castings with emphasis on parts for dairy and other food equipment. To minimize rejects, Waukesha has installed Inducto induction furnaces in its stainless foundry. If you are wondering how a furnace can cut rejects in castings, consider the following facts.

Inducto high-frequency induction furnaces with precision control provide a controllable analysis on alloys. Since the heat is generated in the metal itself, there is no excess or external heat to cause oxidation of some of the alloys. The electromagnetic stirring action of the induction furnace assures a uniform, homogenous alloy. Additionally, melt after melt can be exactly duplicated by the precise control of the Inducto equipment.

At Waukesha, two 650 lb. furnaces and an Inducto Push-Out furnace (not shown) are operated from a 175 KW m-g set and controlled from a single, compact control panel. The tilting furnaces are used for stainless castings while the Push-Out, a unique removable crucible furnace, is used for hard-to-melt non-ferrous alloys.

Design-wise, too, Inducto melting equipment offers many advantages. Learn how you can benefit from the use of the most modern melting equipment available today. Write to:

INDUCTOTHERM corporation

412 Illinois Avenue • Delanco, New Jersey

Personal Mention

Harold W. Paxton

Edward Epremian

The Firth Sterling Chair of Metallurgical Engineering has been established at Carnegie Institute of Technology by Firth Sterling Inc. as part of Carnegie Tech's $25,000,000 development program now under way. The first professor to occupy the Chair will be HAROLD W. PAXTON assistant professor of metallurgical engineering in the Institute and research metallurgical engineer in the Metals Research Laboratory at Carnegie Tech.

Educated in England, he graduated from Manchester University with honors in metallurgy in 1947 and a year later received his master's degree there. Following a year of graduate study at Carnegie Institute of Technology, he returned to England to complete his studies for a doctorate degree at the University of Birmingham, and in 1953 returned once more to Carnegie Tech as a member of the department of metallurgical engineering and the Metals Research Laboratory.

Dr. Paxton is a contributor to many technical magazines, and is currently preparing a chapter for "Precipitation From Solid Solutions", a book to be published by the American Society for Metals. His other A.S.M. activities include membership on the Advisory Committee on Metallurgical Education and on the executive committee of the Pittsburgh Chapter. In addition, he is on several committees of the Institute of Metals Div. of A.I.M.E.

EDWARD EPREMIAN has left the U. S. Atomic Energy Commission in Washington D.C., to join the Metals Research Laboratories of Electro Metallurgical Co., Niagara Falls, N.Y., as a technical advisor on planning and implementing the company's research program.

Ed had been with the division of research of the A.E.C. in Washington, D.C., since 1954 as chief of the metals and materials branch, and prior to that acted as deputy scientific director for the U. S. Office of Naval Research.

A graduate of Massachusetts Institute of Technology (1943), he was a research associate at the General Electric Co.'s research laboratory until 1947 when he received a graduate fellowship at Rensselaer Polytechnic Institute. He received his master's degree a year later, and went on to further graduate study at Carnegie Institute of Technology under a graduate fellowship and a Timken Roller Bearing Fellowship, receiving his doctorate in 1951.

E. L. McReynolds has been named assistant manager of sales for Republic Steel Corp.'s Union Drawn Steel Div., Massillon, Ohio. In this newly created position, he will assist members of the sales staff all over the country in the promotion and handling of alloy and specialty steels. He was a sales engineer in the division Massillon headquarters before his recent promotion.

Walter Burd, a metallurgist with the Carpenter Steel Co., Reading, Pa., has been honored by the Philadelphia section of the American Institute of Mining, Metallurgical, and Petroleum Engineers for the outstanding paper presented by a student at Drexel Institute of Technology. Mr. Burd graduated from Drexel in June and joined Carpenter as a metallurgist in the alloy development section.

Charles B. Gilpin has joined the Bettis plant of the atomic power research laboratory of Westinghouse Electric Corp., Pittsburgh. A recent graduate of the University of Wisconsin, he will be engaged in engineering and development work on the reactor prototype for an atomic-powered aircraft carrier.

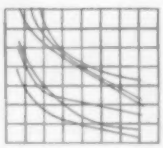
R. C. Heaslett recently retired after 41 years as metallurgist with the foundry and mill division of Blaw-Knox Co., Coraopolis, Pa., and the Continental Foundry & Machine Co. Pittsburgh, Wheeling, W. Va., and East Chicago, Ind. A member of A.S.M. for over forty years, Mr. Heaslett now lives in Tucson, Ariz.

Roy Gordon, executive vice-president and director of the International Nickel Co. of Canada, Ltd., and the International Nickel Co., Inc., has been elected to the Board of Directors of the Babcock & Wilcox Co., New York. Mr. Gordon will also be honored by the American Institute of Mining, Metallurgical, and Petroleum Engineers at the annual A.I.M.E. banquet in New York. He will be awarded the James Douglas Gold Medal for 1958 for "distinguished contributions to process metallurgy in the field of smelting and refining of nickel, and metallurgical improvements in nickel recovery".

Donald N. Rosenblatt, chief metallurgist for the American Foundry & Machine Co., Salt Lake City, Utah, was awarded $1,000 and a gold certificate in Class II of the Third Product Development Contest of the Steel Founders' Society of America at the society's annual fall meeting for his paper on steel castings in mining equipment. Another member, **Robert Eichenberg**, chief engineer of the McEvoy Co., Houston, Tex., received a $400 award and bronze certificate for his Class I paper.

What every good metal man should know about CARBONITRIDING

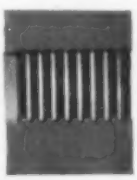
First of all, it is a good idea to know what equipment will do the best carbonitriding job for your specific requirement. And the best way to find this out is to talk over your problems with the people who have consistently developed the methods and equipment for better, more dependable, more economical carbonitriding results. That would be Lindberg.



Let's look at the record. Lindberg's contributions to carbonitriding and carburizing go far beyond just the building of furnaces to do it. It covers the development of controlled atmosphere generators, the creation of dew point equilibrium curves to establish proper atmosphere values for type of steel and temperatures involved and the exclusive Lindberg Carbotrol to maintain these values automatically in production.

Typical installation of Lindberg Hyen Atmosphere Generator, Lindberg Carbotrol and Lindberg Carbonitriding Furnace.

Then there is the invention of the "dimple" vertical radiant tube which gave new efficiency and economy to fuel-fired atmosphere furnaces. Lindberg's exclusive CORRTHERM electric heating element made practical the use of electricity in atmosphere furnaces.



Add to this our record over the years of building a broad variety of carbonitriding and carburizing furnaces, big ones, small ones, manuals, automatics, fuel-fired, electric, and it seems it's just good common sense to bring your heat treating problems to us. Just get in touch with the Lindberg Field Representative in your locality or write:

LINDBERG ENGINEERING COMPANY

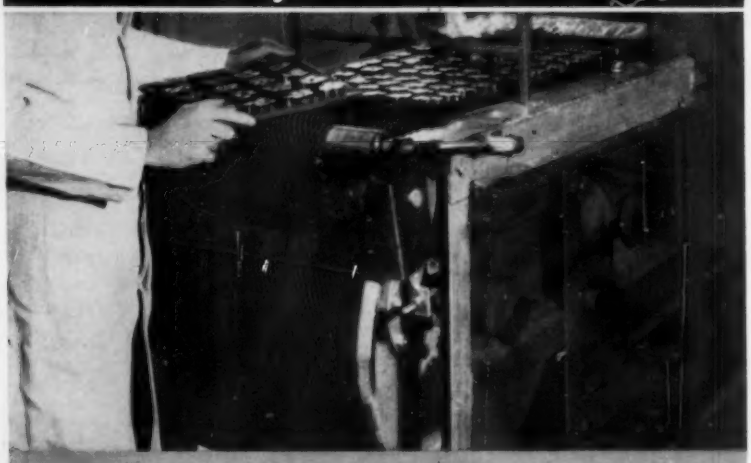
2448 West Hubbard St., Chicago 12, Illinois

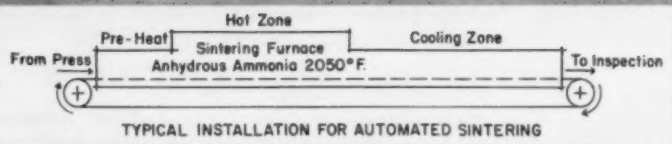
Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.

LINDBERG

heat for industry

Cambridge WOVEN WIRE BELTS





TYPICAL INSTALLATION FOR AUTOMATED SINTERING

METAL-MESH BELTS CUT OPERATING COSTS IN CONTINUOUS HEAT TREATING

Moving through a fiery 2050° F. temperature to fuse metal powders, Cambridge Woven Wire Belts easily resist heat and flame to give long service life, less maintenance, continuous, uniform production. Belt-to-belt flow of products through various heat treating operations eliminates costly manual handling, batch processing for faster, more economical production.

In annealing, quenching and washing operations, Cambridge belts help increase product uniformity and maintain capacity production. Here's why:

OPEN MESH ALLOWS FREE CIRCULATION OF HOT GASES, LIQUIDS through belt and around product for faster, more uniform processing; quench and wash solutions drain freely, thoroughly.

ALL-METAL CONSTRUCTION IS HEATPROOF, ACIDPROOF—takes up to 2100° F. temperatures; resists corrosive attack; has no seams, lacers or fasteners to break.

SPECIAL SURFACE ATTACHMENTS AVAILABLE—raised edges or cross flights to hold product on belt during movement.

Talk to your Cambridge FIELD ENGINEER soon—he'll explain the many advantages of continuous heat treating on Cambridge belts. And, he'll recommend the belt size, mesh or weave—in the metal or alloy—best suited to your operations. You'll find his name in the classified phone book under the heading "BELTING, MECHANICAL". Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department 8, Cambridge 2, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Personals . . .

Kenneth A. Matticks has been assigned to the newly created position of manager of product development, stainless steel sales division, Crucible Steel Co. of America, Pittsburgh. Mr. Matticks has been with Crucible since 1944 and for the past eight years has been a stainless contact metallurgist in the central metallurgical office in Pittsburgh.

Joseph S. Pendleton, Jr., has been promoted from sales service metallurgist to metallurgist, tool and alloy steels, with the Carpenter Steel Co., Reading, Pa. He joined Carpenter in 1939 after graduation from Princeton University and has been sales service metallurgist for ten years.

J. R. Vogt has joined the sales department of Electro Metallurgical Co. as a metallurgical service representative, assigned to the nonferrous section of the metallurgical service division in Cleveland. Before joining Electromet, he was plant metallurgist in the castings division at Bohn Aluminum and Brass Corp., Detroit.

David Turnbull, manager of the chemical metallurgy section at the General Electric Co. Research Laboratory, Schenectady, N.Y., has been granted six-months leave to study and lecture at Cavendish Laboratory at Cambridge University in England. This "research leave" is part of a new program designed to give outstanding scientists at the Research Laboratory an opportunity to spend six months in postgraduate studies at leading universities here and abroad. Dr. Turnbull has been a member of the laboratory staff since 1946 and has held his present position since 1950.

H. Edward Fuhrmeister has left the titanium section of Allegheny Ludlum Steel Corp., Brackenridge, Pa., to take up the position of mill metallurgist at the Toronto, Ohio, plant of Titanium Metals Corp.

John L. Lamont is currently manager of the technical services group of the Metals Research Laboratories of the Electro Metallurgical Corp., Niagara Falls, N.Y., a division of Union Carbide Corp.

Here's the work-horse

for many a carbonitriding job

This furnace has complete automatic cycle and quench control.

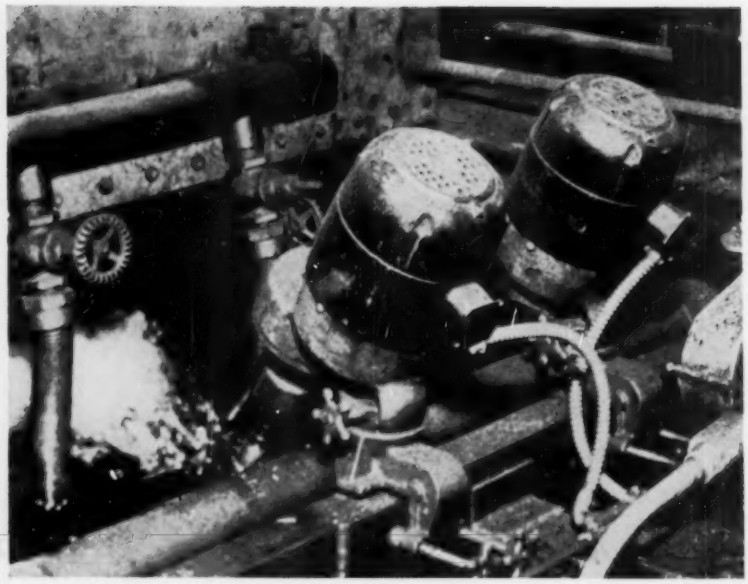
This is the most widely-used carbonitriding furnace of all. Day in and day out production of tons and tons of work has proved this furnace's ability to increase production quality and volume and reduce costs. It is a versatile furnace, too, not only for carbonitriding but for other uses, carburizing, annealing, carbon restoration and many hardening applications.

This type of furnace is available for both manual and automatic operation. It can be equipped either with Lindberg's efficient new vertical radiant tubes for fuel-firing or for electric heating with Lindberg's revolutionary new CORRTHERM element.

Versatile as this furnace is, we don't claim it is the best solution to *every* carbonitriding problem. But, whatever your need may be, talk it over with Lindberg. Our engineers, as they have done in so many instances, will recommend a sound answer—design it, build it, even field-install it if you wish. Just get in touch with the Lindberg plant or the Lindberg Field Representative in your locality. Lindberg Engineering Company, 2448 West Hubbard St., Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.

LINDBERG

heat for industry



WHIPPING UP the BATH...
for the best quench results

Tests show you *should* whip up the quench bath. It results in better, more uniform quenching than you can possibly get in a still bath.

Violent agitation can best be obtained with LIGHTNIN Mixers. You get a much higher rate of quenchant flow with LIGHTNINs than with other methods using comparable power input. And you get a uniform turbulence which wipes and wets every surface of the part being quenched. All surfaces cool at the same rapid rate, giving your part a uniform hardness.

Match your quench needs

For the *best* heat treating results, install LIGHTNIN Mixers on your quench tank. They're available in a variety of sizes and types. You can choose the ones you need for use with any quenchant, and for any type of immersion quenching, martempering or austempering.

If you feel that controlled turbulence can improve *your* quench results, contact your nearest LIGHTNIN representative (listed in Thomas' Register). Or write direct.

PERMANENT...
Often used as a component of new quench tanks and heat treating furnaces. Sizes ¼ to 3 HP.

PORTABLE...
These LIGHTNINSs fit existing tanks and adjust easily to the best angle for uniform turbulence. Thirty models; sizes ⅛ to 3 HP.

SIDE ENTERING...
For large quench tanks; single or multiple installation. Sizes 1 to 25 HP.

Lightnin Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc.
171-b Mt. Read Blvd., Rochester 11, N. Y.
In Canada: Greey Mixing Equipment, Ltd., Toronto 10, Ont.

Personals . . .

Edgar D. Flintermann was recently elected vice-president of the Murmanill Corp., Dallas, Tex. His new duties will include the direction of a pilot ore reduction plant at Longview, Tex., operated by Madiron, Inc., a subsidiary of Murmanill. Mr. Flintermann was executive vice-president and treasurer of Detroit Gray Iron Foundry Co., Detroit, before he accepted this post.

J. T. Teed has been placed in charge of the new eastern sales division of Minneapolis-Honeywell Regulator Co., with headquarters in Philadelphia. Mr. Teed joined Honeywell as an industrial salesman in Tulsa in 1951 after graduation from Texas A. & M., and for the past three years has been manager of the Tulsa branch office.

T. G. Odekirk, a recent graduate in metallurgical engineering from the University of Utah, is now on active duty with the U.S. Navy as an ensign. He is stationed aboard the U.S.S. Tingey as damage control assistant and repair division officer.

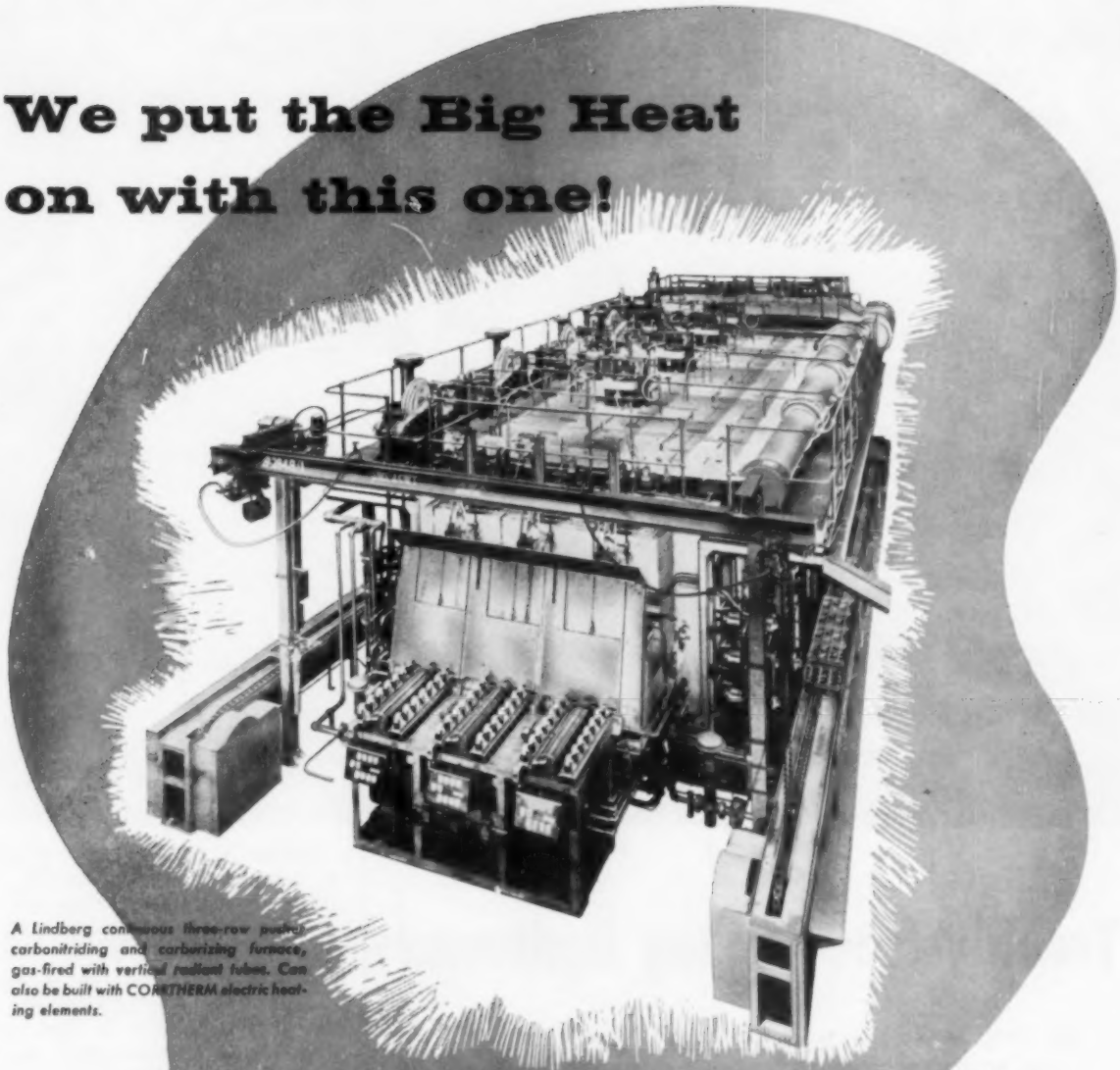
Paul R. Gouwens has joined the metals research department of Armour Research Foundation of Illinois Institute of Technology, Chicago, as supervisor of the foundry and steelmaking section. Mr. Gouwens comes to the Foundation after 17 years with the Fahralloy Co., Harvey, Ill., where he worked in several foundry and engineering departments, rising to the post of chief metallurgist.

Arthur D. Lassila, a graduate student in metallurgy at the Northwestern University Technological Institute, has been awarded the Peter L. Simpson Memorial Fellowship for the 1957-58 academic year. He received a bachelor of science degree last spring at Michigan College of Mining and Technology.

Doyle Geiselman has been assigned to the metals research group of the Metals Research Laboratories, Electro Metallurgical Co., Niagara Falls, N.Y. Dr. Geiselman will serve as a research metallurgist.

T. M. Leigh is now staff engineer for Link-Belt Speeder Corp., Cedar Rapids, Iowa.

We put the Big Heat on with this one!



A Lindberg continuous three-row pusher carbonitriding and carburizing furnace, gas-fired with vertical radiant tubes. Can also be built with CORATHERM electric heating elements.

If your carbonitriding or carburizing problem is a big one, better talk it over with Lindberg. The broad experience of our engineering staff in the development of methods and equipment for every heat treating function offers a pretty sure promise of the most practical answer to it. Particularly where field installation is advisable our combination of engineering know-how and sound installation experience is especially valuable to you.

Whether your requirement will call for the installation of a big baby like the one shown above or a complete heat treating department of smaller units, Lindberg will handle the job all the way. We specialize in "turn-key" installations, covering everything from design and engineering to the finished ready-to-go-to-work job complete with all the construction needed to fit the heat treating equipment into your production processes. Pass your problem to Lindberg. Get in touch with Lindberg Industrial Corporation, 2321 West Hubbard Street, Chicago 12, Illinois, or your local Lindberg Field Representative. Los Angeles Plant: 11937 S. Regentview Ave., at Downey, California.

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heat for industry

WATER SAVING
with
Trouble-Free Cooling Equipment

● Cools your jacket water for engines or process equipment or electric apparatus. Your closed system keeps free from dirt or maintenance troubles. You can cool air, gases, chemicals, plating baths, quench baths, welding machines, extrusion and drawing machines and hydraulic presses. You get real precise temperatures, save rejections, lower production costs. Use NIAGARA *AERO* HEAT EXCHANGER cooling with atmospheric air . . . saves water, pumping, piping and power; quickly saves its costs.

Convenient Units up to 30,000,000 BTU Capacity. Write for Bulletin No. 132.

NIAGARA BLOWER COMPANY
Dept. MP-2, 405 Lexington Ave., New York 17, N. Y.
Niagara District Engineers in Principal Cities of U. S. and Canada

Personals . . .

William J. Harris has retired from Studebaker-Packard Corp., South Bend, Ind. He will be retained by the Falleen Drop Forge Co., Inc., Manistee, Mich., as technical advisor to the president.

H. W. Wyatt has accepted a post with a new division of Avco Mfg. Corp., in the research and advanced development division, as senior scientist and group leader in charge of physical testing and metallography. Facilities for the new division will be located in Wilmington, Mass.

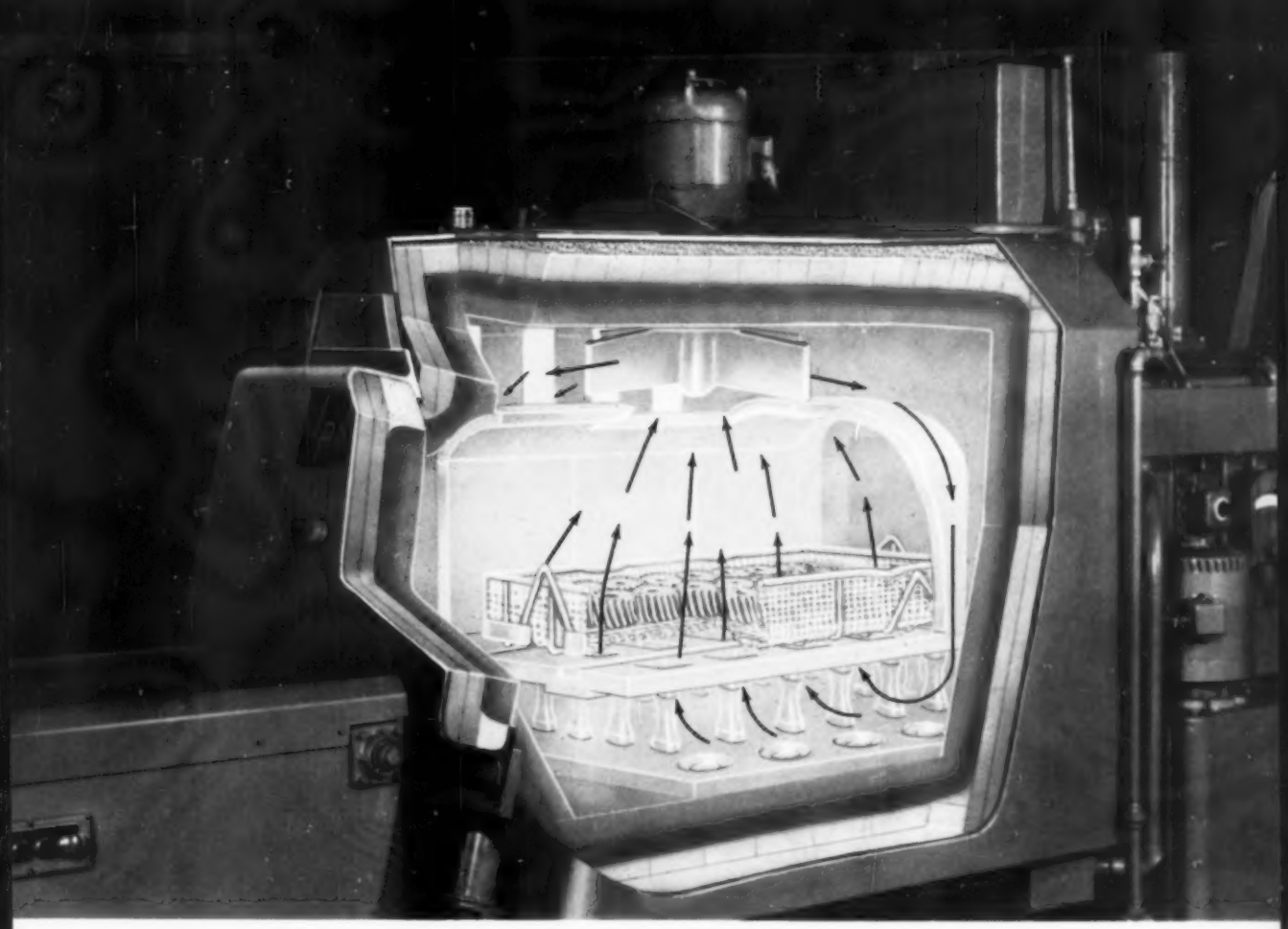
Maxwell Gensamer, professor of metallurgy at Columbia University, has been named Howe Memorial Lecturer for 1958 by the American Institute of Mining, Metallurgical, and Petroleum Engineers at the society's annual meeting. Dr. Gensamer has served on the faculty of Carnegie Institute of Technology and Pennsylvania State University, and was associated with Carnegie-Illinois Steel Corp. before accepting a position as professor at Columbia.

William R. Johnson has been appointed chief research metallurgist at Associated Spring Corp.'s research center in Bristol, Conn., where he will be responsible for basic research. He has been a research metallurgist for the corporation's Wallace Barnes Co. Div. in Bristol for the past four years, and before that was connected with Armour Research Foundation of the Illinois Institute of Technology.

W. G. Dahl has been promoted to general sales manager of Latrobe Steel Co., Latrobe, Pa. Mr. Dahl, who joined the company after service in the U. S. Navy during World War II, had held the position of eastern regional sales manager with headquarters in Hartford, Conn.

James L. Roach has assumed new duties as general sales manager of Wyman-Gordon Co., with headquarters in Detroit. A graduate of Carnegie Institute of Technology, he joined the company in 1939.

Laird Gale has been named chemist-metallurgist in charge of the laboratory of the Kay Brunner Metal Product Co., Alhambra, Calif.



Superior controlled atmosphere heat treating

. . . with Ipsen 100% forced convection

100% forced convection heating and exclusive alloyed ceramic heating tubes have been successfully combined in all Ipsen furnaces for special atmosphere carburizing, carbo-nitriding, heat treating, brazing or sintering, and other applications calling for temperatures up to 2500° F.

Here's what happens when a cold charge goes into an Ipsen furnace. Stored heat from the furnace walls is forced into the heating chamber to the work being heated. This causes the furnace temperature to fall until the furnace wall, the heating chamber, and the charge all reach the same temperature. Then the high velocity heat which is carried to every part of the heating chamber and the charge simultaneously raises the temperature of both the heating chamber and charge back to the desired control temperature.

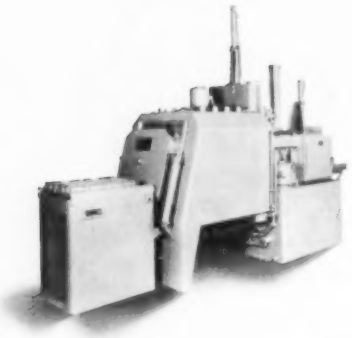
100% forced convection heating insures *uniform heating of every part of the charge* . . . whether it's loosely or densely packed. Both light and heavy sections are uniformly heated.

Ask for literature describing Ipsen 100% forced convection furnaces.

AUTOMATIC Ipsen HEAT TREATING UNITS

following page shows 100% forced convection chart

how Ipsen 100% forced convection works . . .



This centrifugal roof fan, powered by a husky, slow-starting motor, circulates the protective atmosphere . . .

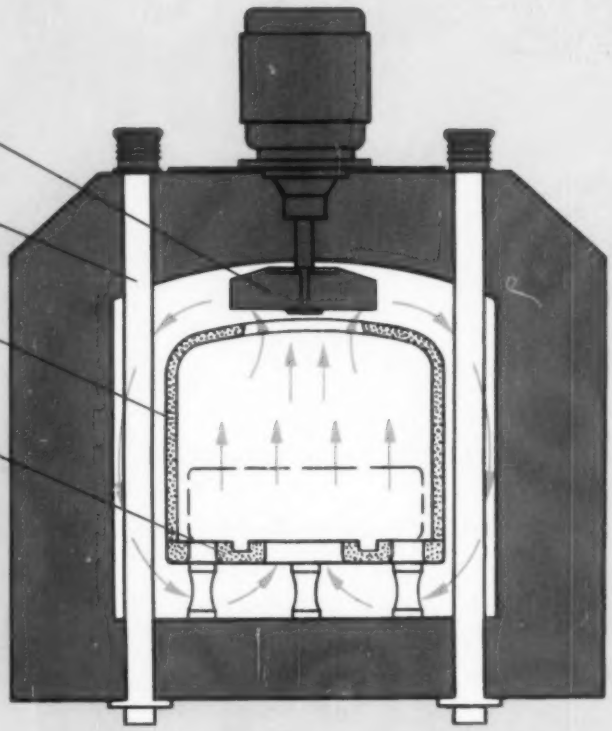
down past these vertical alloyed ceramic heating tubes . . .

which are isolated from the work chamber by this baffle . . .

to the bottom of the furnace and then up through this heavy, open grid-hearth . . .

to all parts of the charge where correct working temperature is maintained.

Work is brought to heat uniformly . . . controlled atmosphere is forced to all parts of the charge.



Write for technical brochures describing Ipsen 100% forced convection furnaces.

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. • 723 S. MAIN STREET • ROCKFORD, ILLINOIS

"...AND WEIRKOTE® CAN DO AWAY WITH PLATING OR DIPPING AFTER FABRICATION! IT WON'T PEEL OR FLAKE."

Q. A zinc-coated steel that won't peel or flake? That could save us a lot of money every month. Just what makes this Weirkote so special?

A. It's made by the continuous process, you know, which integrates zinc and steel so that the toughest fabrication won't break down the bond. You can work Weirkote to the very limits of the steel itself.

Q. Of course, that means the most complicated parts would have protection against rust. I like what I'm hearing. Is there more?

A. Yes . . . now Weirkote is treated to inhibit wet storage stain (white oxide). To make a long story short, I'd say this: With Weirkote, you can turn out a better product at lower cost. And you can free a lot of the capital, floor space and time you have tied up in plating operations.

Send for free booklet that details the time- and cost-saving advantages of skin-tight zinc-coated Weirkote. Weirton Steel Company, Dept. S-7, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

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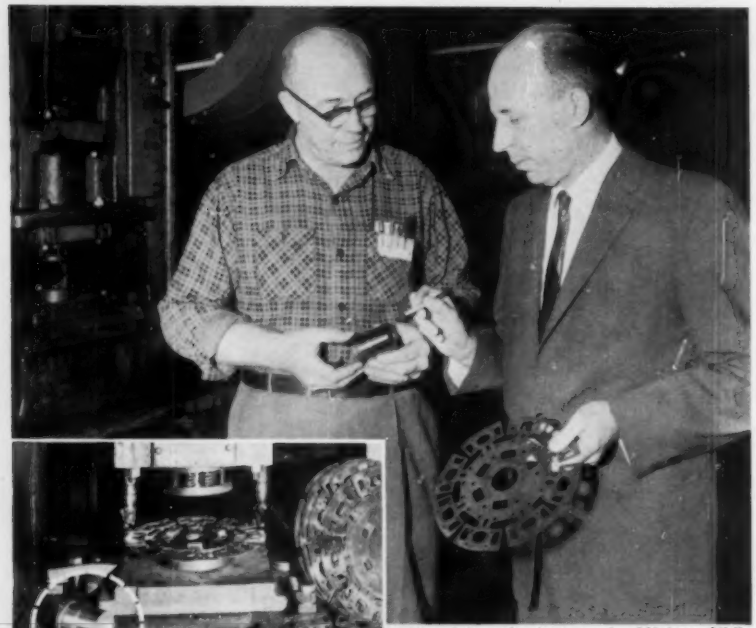
NATIONAL STEEL CORPORATION

Proof of Vulcan Tool Steel Superiority



Examining piercing punch of Vulcan Alidie High Carbon-High Chrome Tool Steel are Ralph Claypool, left, stamping foreman, Long Manufacturing Division, Borg-Warner Corp., and Tom Varley, right, Vulcan Sales Engineer.

35 ton Stoll Press die assembly enlarges and trims center holes in pre-hardened clutch plate.

REDUCES TOOL MAINTENANCE COSTS BY 87%...

Vulcan Alidie Tool Steel!

Vulcan sales engineers, cooperating with engineers of Long Manufacturing Division, Borg-Warner Corporation, reduced sharpening of die and punch tools from *once every 2 days to once every 15 days.*

Long Manufacturing Division produces clutch plates for commercial vehicles and industrial trucks. Pre-hardened material is SAE 1065, with a hardness of 41/46 Rockwell C. Thicknesses range from .040" to .090" x various diameters.

Costs and downtime were lowered because Vulcan engineers recommended the *right* steel for the job. Vulcan Alidie High Carbon-High Chrome Tool Steel with a hardness of 61/63 Rockwell C. This same engineering help is available to you without charge.

For the name of your nearest Vulcan representative, write, wire, or call collect: *Vulcan Crucible Steel Division, H. K. Porter Company, Inc., Aliquippa, Pa.*

H. K. PORTER COMPANY, INC.

VULCAN CRUCIBLE STEEL DIVISION

Personals . . .

Joseph DeSanto, who joined the Chicago sales staff of the Champion Rivet Co., Cleveland, last June, has now been made manager of welding sales for the Chicago section. Mr. DeSanto was formerly acting regional manager of sales for Metal & Thermit Co. in the Chicago area and before that was general welding foreman at Pullman Standard Car Mfg. Co.

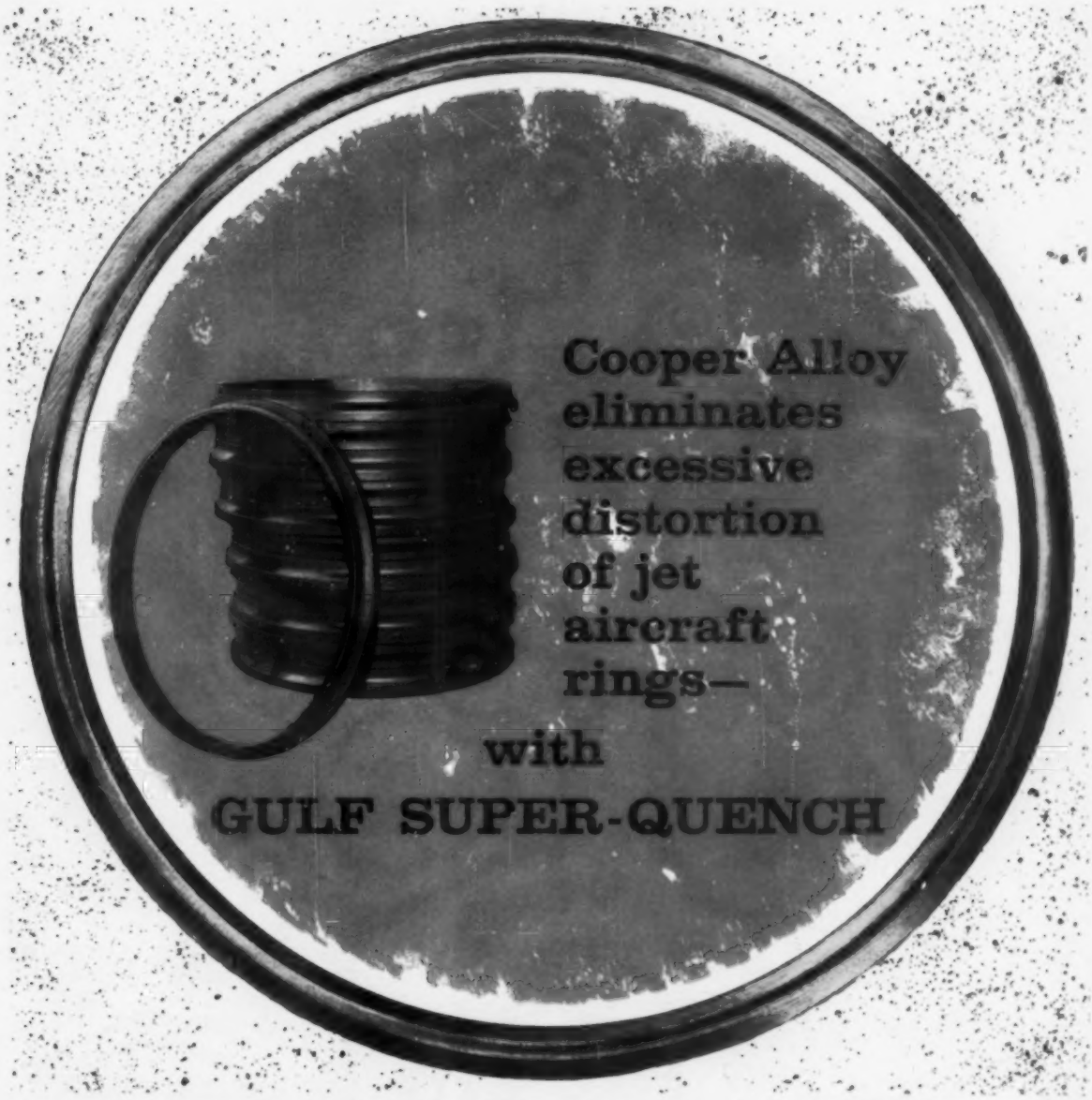
W. B. Farnsworth has been added to the staff of the Linde Tonawanda Research Laboratory, Tonawanda, N.Y., as assistant manager of research. Before accepting this new post, Mr. Farnsworth was manager of gas process development at the Linde Newark Laboratories, and prior to joining Linde was affiliated with Pittsburgh Steel Co.

Robert P. Stuntz has assumed new duties as assistant sales manager of the Babcock & Wilcox Co. refractories division, with headquarters in the executive offices in New York. Mr. Stuntz joined the company in 1940 and since 1951 had served as district sales manager of the Chicago sales office.

William J. Thomas, vice-president and general manager of the tubular products division of the Babcock & Wilcox Co., New York, has been elected to the Board of Directors of the company and placed in full charge of the division.

Kenneth L. Kinser and **James D. McKinnon** have been given new assignments in the sales department of the steel division, Copperweld Steel Co., Warren, Ohio. Mr. Kinser will serve as district sales manager of Copperweld's recently established Indianapolis, Ind., sales office. The new district sales manager of the Chicago sales office will be Mr. McKinnon.

Carl B. Post has been named vice-president and technical director of Carpenter Steel of New England, Inc., Bridgeport, Conn., formerly Northeastern Steel Corp. and now a subsidiary of the Carpenter Steel Co., Reading, Pa. Dr. Post began his career with Carpenter in 1938 and became head of the metallurgical and research departments in 1954. He has been vice-president for the past three years.



Cooper Alloy Corporation has been using Gulf Super-Quench since September, 1956, at its Aircraft Products Division, Clark, New Jersey.

The requirements: harden precision-made jet aircraft rings of 410 stainless in a rapid, uniform cooling operation without excessive distortion or carbide precipitation after solution treatment. This firm, well-known for its extremely high standards of quality, reports: "Gulf Super-Quench performs well where other quenching oils have failed, and it completely satisfies all our requirements."

Gulf Super-Quench offers the desirable properties of high initial quenching speed, in the critical hardening range . . . slow final quenching speed, throughout the lower temperature range . . . and great stability in service. Gulf Super-Quench provides more uniform and more complete hardening, reduction of cracking and distortion—all of which spells increased production, fewer rejects, lower costs.

Find out more about Gulf Super-Quench by calling your Gulf Sales Engineer. You'll find him at your nearest Gulf office.

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Department DM, Gulf Building
Pittsburgh 30, Pa.

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750,000 "ON AND OFFS"

Leading appliance maker chooses miller phosphor bronze for range switch part!

Miller Phosphor Bronze is consistently chosen for the tough jobs—in this instance a switch part that must withstand an estimated 750,000 "on and offs" without fatigue or fracture.

Miller *specializes* in the tailor-made production of phosphor bronze alloys—in strip, coiled and flat lengths—best fitted to your needs. At Miller, Phosphor Bronze is the main line, *not* a sideline.

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ROLLING MILL DIVISION
America's Quality Phosphor Bronze

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SINCE 1844

Personals . . .

Morris E. Fine, professor of metallurgy at Northwestern University Technological Institute, has been appointed chairman of the metallurgy department.

Carlos J. Romero has taken a post as research engineer in the fuel element group of Atomics International Div. of North American Aviation, Inc., Canoga Park, Calif. Before accepting this assignment, he was senior engineer with Sylvania-Corning Nuclear Corp., Bayside, N.Y.

Richard W. Bratt has returned to Crucible Steel Co. of America after 19 months' service at the Brooklyn Navy Yard. He is now employed at the company's metallurgical laboratory in Syracuse, N.Y.

D. E. Brown, formerly an engineer in the machine plant of the Chrysler Corp., New Castle, Ind., has been promoted to laboratory supervisor.

Dale E. Johnson is now working in the technical laboratories unit at Idaho Test Station, Aircraft Nuclear Propulsion Dept., General Electric Co., Idaho Falls, Idaho.

P. W. Snyder has been transferred from duty as U.S. Navy Shipbuilding Representative, Europe, with headquarters in Paris, to the Bureau of Ships, Navy Dept., Washington, D.C., where he is assistant chief of Bureau for Shipbuilding and Fleet Maintenance.

H. M. Johnquest has retired from the Bristol Co., Waterbury, Conn., and now lives in Florida.

B. J. Bastian, formerly a staff metallurgist for the Thomas A. Edison Research Laboratories, is currently a project engineer for the Chrysler Engineering Div., Chrysler Corp., Detroit, where he is in charge of welding research.

James S. Epley is now a product engineer with the Garlock Packing Co., Palmyra, N.Y. He was assistant process engineer with R. K. Le Blond Machine Tool Co. until taking over his new assignment.

R. C. Atherton has accepted a position as production engineer in the foundry division of Zollner Corp., Fort Wayne, Ind.

FOR SPRING STEEL FASTENERS

QUALITY BEGINS WITH SHARONSTEEL

The manufacture of fasteners requires steel of the most exacting analysis. Spring quality steels of just the right degree of hardness to permit volume manufacture of hundreds of complicated and complex shapes.

Leading fastener manufacturers look to Sharon as a first source of supply because they have learned they can rely on Sharon to deliver finest quality to precise specifications — coil after coil.

SHARON STEEL CORPORATION

SHARON, PENNSYLVANIA

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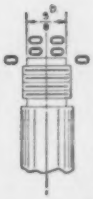
The Lepel line of induction heating equipment represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating.

If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

TYPICAL INDUCTION HEATING APPLICATIONS

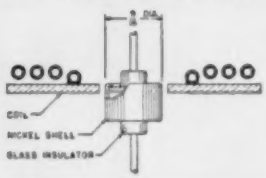
HARDENING
DIESEL FUEL INJECTOR



Restriction of heat to end of holder body for fuel injector permits hardening of face to provide required resistance to deformation without hardening the threads. Coil design shown provides uniform temperature for hardening despite holes in face.

REMOVING
RUBBER FROM STEEL

Induction heating develops uniform temperature at steel-rubber interface destroying bond for easy separation. Steel and rubber may similarly be salvaged from mounting brackets, shock absorbers, etc.



SOLDERING TRANSISTOR ASSEMBLIES

Concentrator-type coil creates high intensity, restricted heating at joint of nickel shell and tinned glass, thus causing solder flow for permanent seal.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

Personals . . .

D. W. Wells is now a manufacturer's representative for Cleveland Worm & Gear Co., Farval Corp. and American Flexible Coupling Div. of Zurn Industries, Inc.

Josef Intrater, formerly on the staff of Rutgers University, has been elected vice-president in charge of research of the Materials Research Corp., Yonkers, N.Y.

Paul N. Browand, after graduation from Purdue University last year, accepted a position as metallurgical engineer with the Reynolds Metals Co. at their Grand Rapids, Mich., extrusion plant.

Stuart T. Ross has been promoted from laboratory supervisor to head of the metallurgical research department of the engineering division, Chrysler Corp., Detroit. His new title is managing engineer.

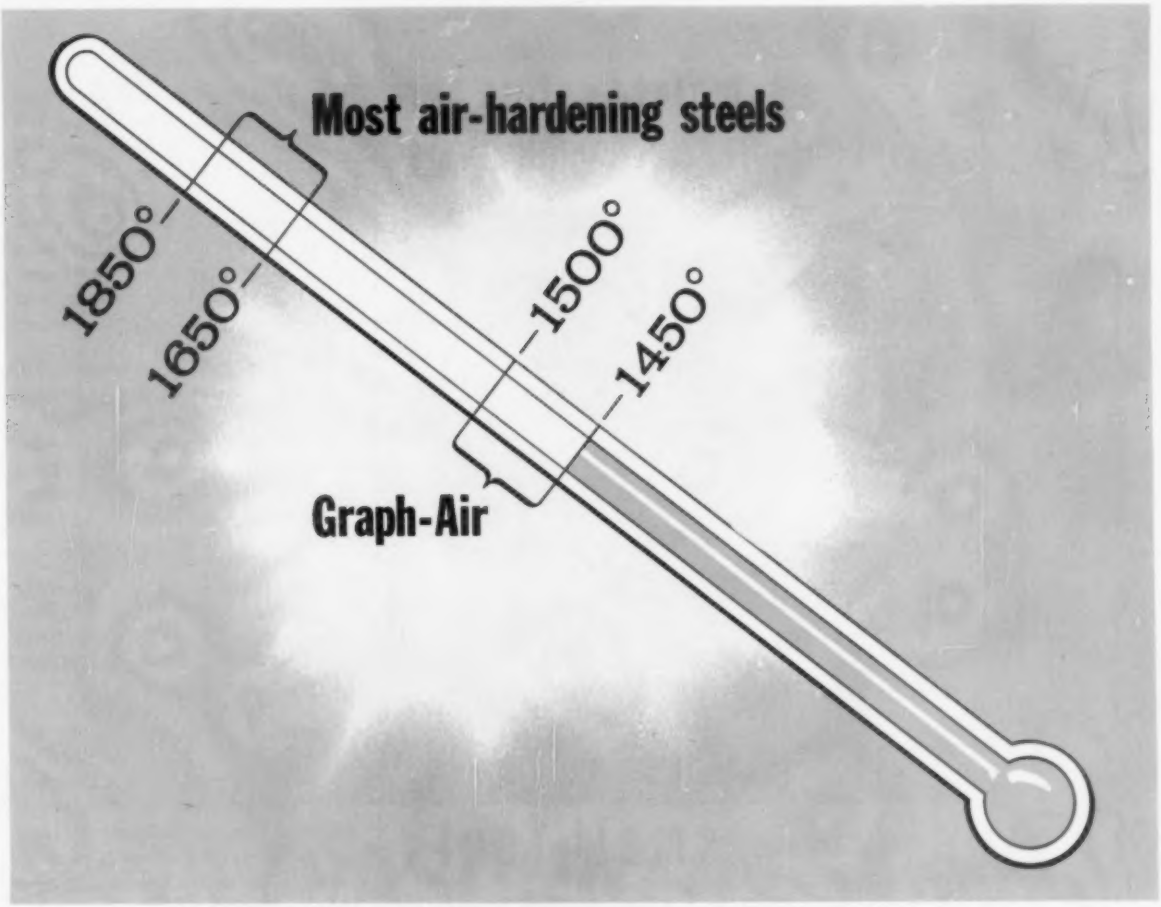
Edward P. Sandbach has been named chief metallurgist for the Mackintosh-Hemphill Div. of E. W. Bliss Co. and now heads the metallurgical departments in the division's Pittsburgh and Midland, Pa., plants. He replaces **Charles C. Peterson** who was recently named manager of manufacturing operations for the two plants.

Alfred D. Stevens is engaged in research and development work on nuclear power plants at the atomic power research laboratory of the Bettis plant, Westinghouse Electric Corp., Pittsburgh.

Charles A. Mueller, after several years engaged in engineering and metallurgical work in Utah and California, has returned to Lindberg Engineering Co., Chicago, as chief engineer of the new gas process division.

William H. Oler has been appointed sales manager of the engineering division of Hauck Mfg. Co., Brooklyn, N.Y. He was formerly regional sales manager for the company for Western Pennsylvania, Ohio and Michigan.

Verne M. Kolba has accepted a post as assistant physicist at Argonne National Laboratory, Lemont, Ill. Mr. Kolba was a senior engineer with the Martin Co., Baltimore, before coming to Argonne.



Graph-Air®... *lowest-temperature air-hardening tool steel reduces distortion*

TEMPERATURE as low as 1450°F. is high enough to air-harden Timken Graph-Air® tool steel. That's as much as 400° lower than most other air-hardening tool steels. Because of this, you reduce distortion and simplify heat treat control. And surface scaling and decarburization are minimized.

Graph-Air machines faster, too, because of its graphitic structure. And it's tougher—outwears ordinary tool steels because of the uniform, diamond-hard carbides in its structure.

With Graph-Air you get longer-lasting accuracy because of its built-in stability. Graph-Air is one of the "family" of Timken Company graphitic tool steels, the most stable ever made.

And the uniformity of hardening and reduced distortion you get with Graph-Air make possible more intricate sections. It's ideal for blanking dies and other parts that must stand up under abuse.

For a high quality tool steel that air-hardens at lowest temperature, specify Graph-Air. Available in solid and hollow bar sizes. For further information, please write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

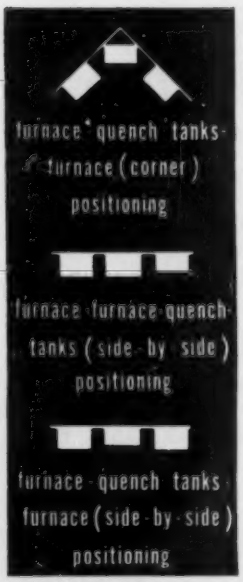
TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Now ...a complete set-up for heat-treating small tools

Waltz small tool furnaces


furnace quench tanks-furnace (corner) positioning
furnace furnace quench-tanks (side-by-side) positioning
furnace quench tanks furnace (side-by-side) positioning

Contains a pre-heat furnace, a high-heat furnace and quench tanks in a unit designed for convenient positioning in your shop. Furnace sections are equipped with casters.

Temperature range permits treatment of all high speed steels including cobalt type.

Waltz small tool furnaces are "money makers" in many shops throughout the country. Enjoy the lucrative advantages of heat-treating facilities right in your own shop.

A complete line of Waltz standard or special heat-treating furnaces using all types of fuels are built to suit your requirements. Write for comprehensive illustrated bulletins.

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Waltz Furnace Co.,
Symmes Street, Cincinnati, Ohio
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Please send without obligation engineering bulletins—Waltz Heat-treating Furnaces.

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COMPANY_____

ADDRESS_____

CITY_____ STATE_____

Waltz furnace company
SYMMES STREET
CINCINNATI, OHIO

Personals . . .

Byron B. Clow has been named forgings product manager for the Chicago plant of Kaiser Aluminum & Chemical Sales, Inc., Oakland, Calif. Since joining Kaiser Aluminum in 1948 as a sales trainee, Mr. Clow has served in various sales management capacities in Kaiser plants throughout the country, and most recently was assistant product manager, forgings, in Chicago.

Paul R. Borneman, supervising research metallurgist at the Dunkirk, N.Y., works of Allegheny Ludlum Steel Corp., Pittsburgh, has been promoted to chief research metallurgist, tool and die steels, at the Dunkirk plant.

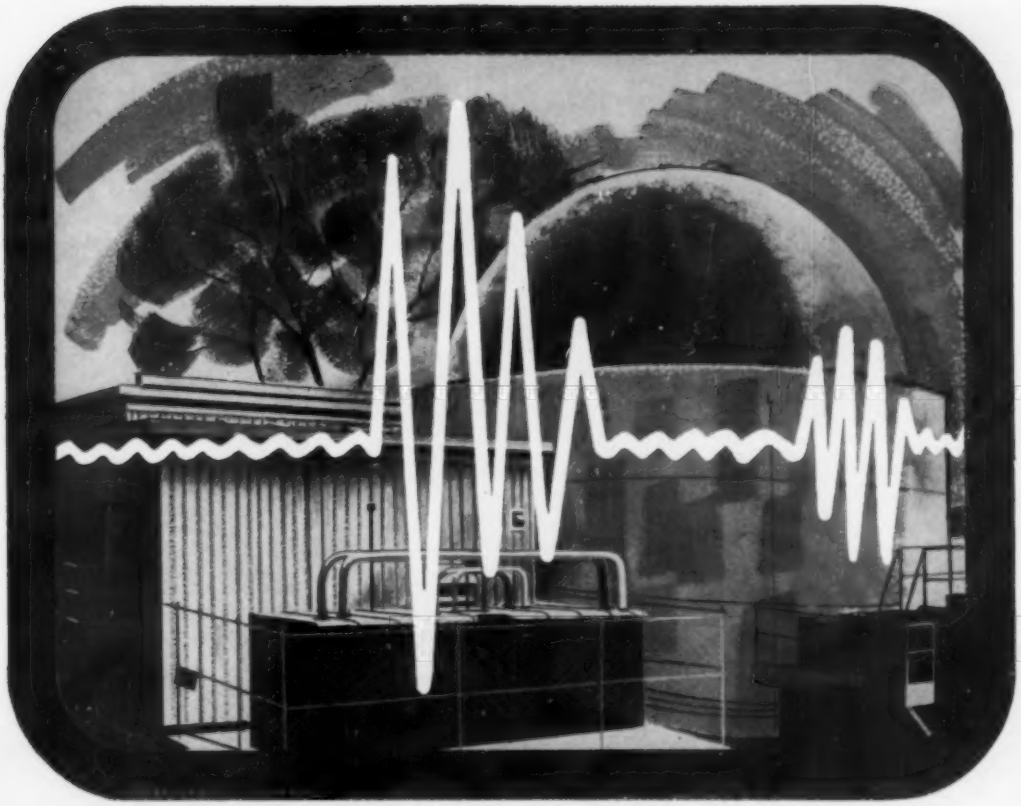
Gaza Demeter was recently elected vice-president of Rex Precision Products, Inc., Culver City, Calif., producers of precision investment castings.

Joseph W. Duba has been appointed assistant manager of the Cincinnati sales branch of the Crucible Steel Co. of America, Pittsburgh. Affiliated with the company for over ten years, Mr. Duba was sales service engineer at the Cincinnati sales branch until his recent appointment.

Charles W. Sherman has accepted the post of senior research associate with Jones & Laughlin Steel Corp., Pittsburgh. He comes to J & L after seven years' experience with Latrobe Steel Co., Latrobe, Pa., in various supervisory positions, including four years as director of research.

William H. McCarty, Jr., has been appointed district manager for Latrobe Steel Co.'s sales and engineering-sales department with headquarters in Boston. Mr. McCarty will have charge of sales in the New England area where he had formerly served Latrobe as salesman.

Stephen K. Tarby and **Gerald Liedl** have been awarded Jones & Laughlin Fellowships for the second consecutive year. Mr. Tarby will continue his work toward a doctorate in metallurgy at Carnegie Institute of Technology, while Mr. Liedl, who is also studying for a doctor's degree, will complete his work at Purdue University.



ULTRASONIC TESTING

HAS O.K.'d MORE THAN TEN MILLION FEET OF STAINLESS STEEL NUCLEAR REACTOR TUBING!

More than 1,800 miles of stainless steel reactor tubing have been tested ultrasonically. At one tube plant alone, Sperry engineers have inspected more than 1,000,000 feet. Its accuracy and reliability are such that ultrasonic inspection is now a standard specification for all reactor tubing.

SAFETY OF CAR DRIVE SHAFTS INSURED BY REFLECTOSCOPE INSPECTION

Welded steel tubing for automobile drive shafts is inspected for soundness of the weld by Sperry Ultrasonic Reflectoscopes with RA attachments. These units scan material traveling at high production speeds, monitoring and recording the weld quality and signaling any deviation from predetermined standards. Automatic marking devices and alarm signals provide a double check on the safety factor.

Equally efficient in contact or immersion use, the Sperry Ultrasonic Reflectoscope provides a simple, nondestructive *and economical* way to locate internal defects in materials. Its versatility, indicated by the two examples of tubing inspection, has been proved in thousands of other applications ranging through quality control, periodic maintenance, laboratory investigations, etc.

FOR INFORMATION ABOUT THIS INSPECTION TOOL, FILL OUT AND MAIL THE COUPON.

Sperry

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Danbury, Conn.
First in Ultrasonic Inspection

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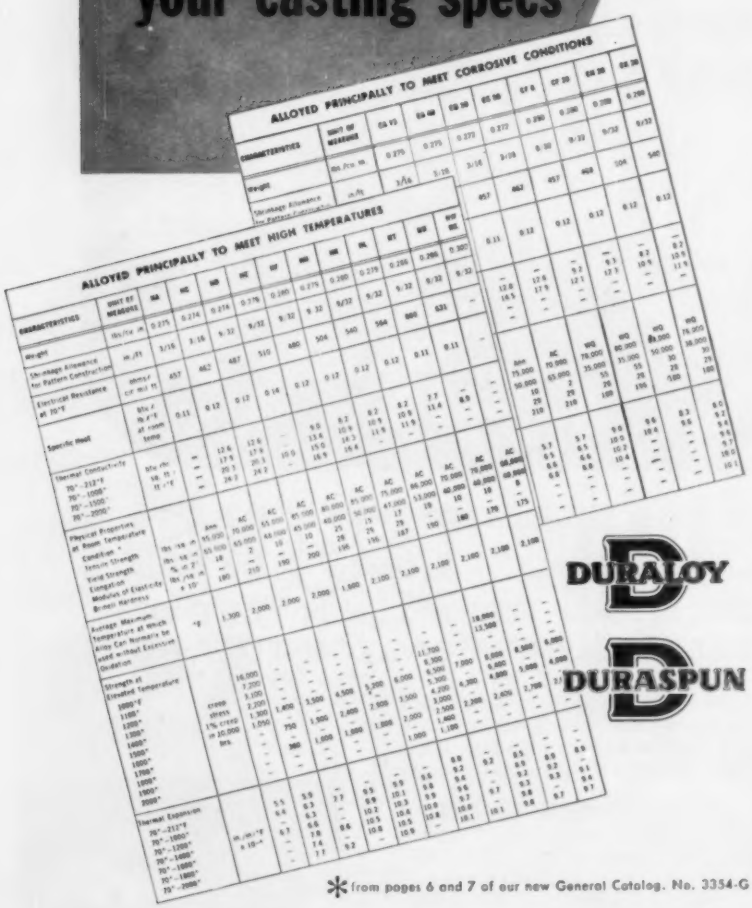
*TABLES to help you select the proper alloy for your casting specs



ALLOYED PRINCIPALLY TO MEET CORROSIVE CONDITIONS

CHARACTERISTICS	UNIT OF MEASURE	CA 15	CA 40	CB 30	CE 30	CF 8	CF 20	CH 20	CK 20
Weight	lbs./cu. in.	0.275	0.275	0.272	0.272	0.280	0.280	0.280	0.280
Shrinkage Allowance for Pattern Construction	in./ft.	3/16	3/16	3/16	3/16	5/32	5/32	5/32	5/32
Electrical Resistance at 70°F	ohms/cir. mil ft.	457	462	457	462	457	462	504	540
Specific Heat	Btu/lb/°F at room temp.	0.11	0.12	0.12	0.12	0.11	0.12	0.12	0.12
Thermal Conductivity 70°–212°F	Btu/hr./sq. ft./in./°F	—	—	—	—	—	—	—	—
70°–1000°F		—	12.6 16.5	—	—	—	12.6 17.9	—	—
70°–1500°F		—	—	—	—	—	—	—	—
70°–2000°F		—	—	—	—	—	—	—	—
Physical Properties at Room Temperature Condition		Ann.	AC	AC	WQ	WQ	WQ	WQ	WQ
Tensile Strength	lbs./sq. in.	75,000	70,000	65,000	75,000	70,000	80,000	80,000	75,000
Yield Strength (Offset)	lbs./sq. in.	30,000	63,000	35,000	35,000	35,000	35,000	50,000	30,000
Elongation	% in 2"	10	2	8	10	8	10	30	30
Modulus of Elasticity	lbs./sq. in. x 10^6	25	25	25	25	25	25	25	25
Brinell Hardness		210	210	210	210	210	195	150	150
Average Maximum Temperature at Which Alloy Can Remain in Load without Excessive Oxidation	°F	1,300	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Strength at Elevated Temperature 1000°F	creep stress, 1% creep in 10,000 hrs.	16,000	—	—	—	—	—	—	—
1100°		7,200	—	—	—	—	—	—	—
1200°		3,100	—	—	—	—	—	—	—
1300°		2,200	—	—	—	—	—	—	—
1400°		1,300	—	—	—	—	—	—	—
1500°		1,050	—	1,400	4,500	3,200	6,000	—	—
1600°		—	—	750	—	2,500	—	—	—
1700°		—	—	—	2,600	—	3,500	11,700	6,300
1800°		—	—	300	1,000	1,000	2,000	6,300	4,200
1900°		—	—	—	—	—	1,000	4,200	3,000
2000°		—	—	—	—	—	—	2,500	2,000
		—	—	—	—	—	—	1,600	1,200
Thermal Expansion 70°–212°F	in./in./°F x 10^{-6}	5.5 6.8	5.9 6.3	—	—	—	—	—	—
70°–1000°F		6.3	6.6	7.7	—	—	—	—	—
70°–1200°F		—	7.4	—	—	—	—	—	—
70°–1400°F		—	7.7	8.6	9.9	9.9	10.1	10.1	10.1
70°–1600°F		—	—	9.2	10.2	10.2	10.5	10.4	10.5
70°–1800°F		—	—	—	10.5	10.6	10.9	10.5	10.9
70°–2000°F		—	—	—	—	—	—	10.8	—

DURALOY

DURASPUN

*from pages 6 and 7 of our new General Catalog. No. 3354-G

— and there's lots more useful information about high alloy castings in our up-to-date catalog describing Duraloy Service. SEND FOR YOUR COPY.

As one of the pioneers in both static (1922) and centrifugal (1931) high alloy castings, we have a wealth of experience to focus on your high alloy casting problem. Send for our catalog, study it, and then let us help you get the best alloying combination to solve your corrosion, high temperature and/or abrasion problem.

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CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Personals . . .

H. O. B. Shiller has been appointed general manager of A & C Process Co., West Los Angeles, Calif., where he will be concerned with special metal applications on glass. He still remains general manager of the Shiller Glass Works in North Hollywood, Calif.

John F. Thompson, chairman of the Board of International Nickel Co. of Canada, Ltd., will be recipient of the Charles F. Rand Memorial Medal for 1958, awarded by the American Institute of Mining, Metallurgical, and Petroleum Engineers in recognition of his distinguished achievement in mining administration. Dr. Thompson's career with Inco began in 1906 when he joined the company as a metallurgist. In 1949 he was named president, retiring from this post in 1952.

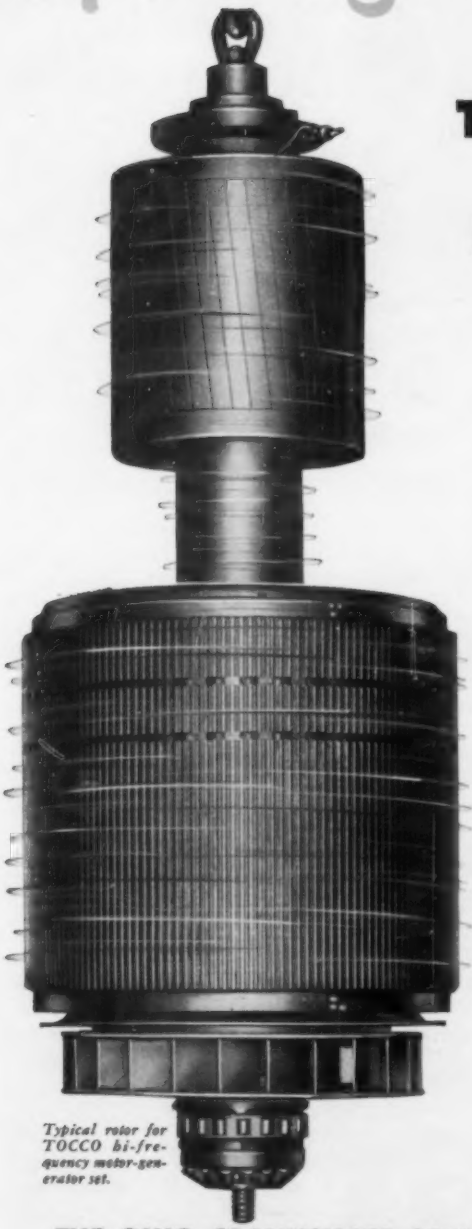
John H. Moorman has been named to head the new research laboratory for fundamental study of the die casting process, organized by the Aluminum Co. of America at its Chicago works. The facility will function as a section of the Cleveland Research Division of Alcoa Research Laboratories. Mr. Moorman began his career at Alcoa in 1941 at the Garwood, N.J., works as production metallurgist and in 1948 was named chief metallurgist of the plant.

Severn W. Kittredge has transferred from the Brainard Steel Div. of Sharon Steel Corp. to the parent company in Sharon, Pa., as assistant chief engineer. He joined Brainard in 1946 and last served as superintendent of the Larchmont plant of the division.

J. D. Nisbet, one of the pioneers in the vacuum metallurgy industry, is now head of the recently organized Allvac Metals Co. in Monroe, N.C. Allvac will specialize in the production of vacuum melted alloys for high temperature applications.

W. J. Stephens has been named branch manager of the new mill branch warehouse and office of the Carpenter Steel Co., in Chicago. The new installation will be midwestern headquarters for both the main company and its Alloy Tube Division.

Spinning for over 15 Years!



Typical rotor for TOCCO hi-frequency motor-generator set.

TOCCO's VERTICAL Hi-Frequency Motor-Generator Sets

First with Vertical MG Sets—TOCCO*

In 1943 TOCCO designed and built the first vertical motor-generator sets for furnishing hi-frequency power for induction heating applications. Now with fifteen years of continuous production experience, we are far and away the world's largest supplier of these units. Over 1000 are now in service.

Advantages of TOCCO Vertical MG Sets

The large TOCCO vertical type motor generator set has numerous advantages over conventional horizontal type sets. Vertical construction permits the use of very large bearings and also minimizes the hazard of major damage to the set in the unlikely event of a bearing failure. Longer bearing life is achieved due to lower pressure and uniform loading of the bearings. Maintenance is greatly simplified because the rotor can be removed vertically with a simple hoist. Anti-vibration mountings between the base and the MG rotor-stator assembly practically eliminate vibration. No special foundations are needed. Lastly, TOCCO's vertical design cuts necessary floor space to less than one-half the area required by horizontal motor-generator sets.

Only Time-Tested Vertical MG Sets—TOCCO

There are over a thousand TOCCO vertical MG sets in actual service TODAY—more than all competitive horizontal makes combined. Write us for descriptive bulletin giving full details on the advantages and construction details of TOCCO vertical MG sets.

TOCCO vertical MG sets are available in sizes up to 350 KW and frequencies from 1000 to 10,000 c.p.s.

THE OHIO CRANKSHAFT COMPANY

TOCCO

*Trade Mark Reg. U. S. Pat. Off.

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NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. M-2, Cleveland 5, Ohio

Please send copy of "TOCCO Hi-Frequency Motor-Generator Sets."

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Digests of Important Articles

Forging Heat Treatment

Digest of "The Heat Treatment of Forgings", by A. O. Schaefer, *Metal Treating* Vol. 7, September-October 1956, p. 6-8, 21-24.

ALTHOUGH open-die forgings account for only about 1% of the country's steel production, the product and the problems are king-sized. Many of the forgings are unusually large, ranging up to 75 ft. in length or several feet in diameter. In fact, some big forging ingots require more hot metal than can be supplied by one heat from an average-sized electric or openhearth furnace. Failures in such huge forgings are so expensive and dangerous that extreme care must be taken in all stages of manufacture. This article deals with heat treatment which is one of the principal factors affecting structural quality of the final product. The problems in heat treating large forgings are chiefly concerned with avoiding flakes or fissures, developing sufficient strength and securing dimensional stability.

Flakes are still a problem in the manufacture of large forgings despite the attention given to preventing their occurrence. Flakes can be described as disk-shaped fissures or cracks which are usually oriented radially in large masses of steel. Defects which are similar in nature are termed "fisheyes" or "bright spots"' when they occur in castings. The concensus is that flakes are caused by the combined presence of excessive hydrogen contents and transformation stresses at temperatures below that at which martensite forms on cooling. The maximum safe hydrogen content is not known. The formation of flakes may not appear for some time, necessitating an incubation period as long as a month after large forgings have cooled to room temperature. This phenomenon obviously increases the difficulty of detecting such defects. Early attempts to prevent the formation of flakes by using immunizing heat treatments between forging operations were not entirely successful. It is now realized that certain principles must be observed during every stage of heat treatment.

In order to avoid flaking, the forging industry now avoids rapid or uncontrolled cooling of large ingots and forgings. After forging to the desired shape, the hot forging is charged into a furnace at 1200° F., held for temperature equalization, and cooled no faster than 30° F. per hr. to a temperature in the range of 600 to 450° F. The forgings are held at a suitable temperature in this range until transformation is complete. The proper temperature is slightly above the temperature at which martensite forms and varies slightly with steel composition. Temperatures in this range are said to favor the removal of hydrogen.

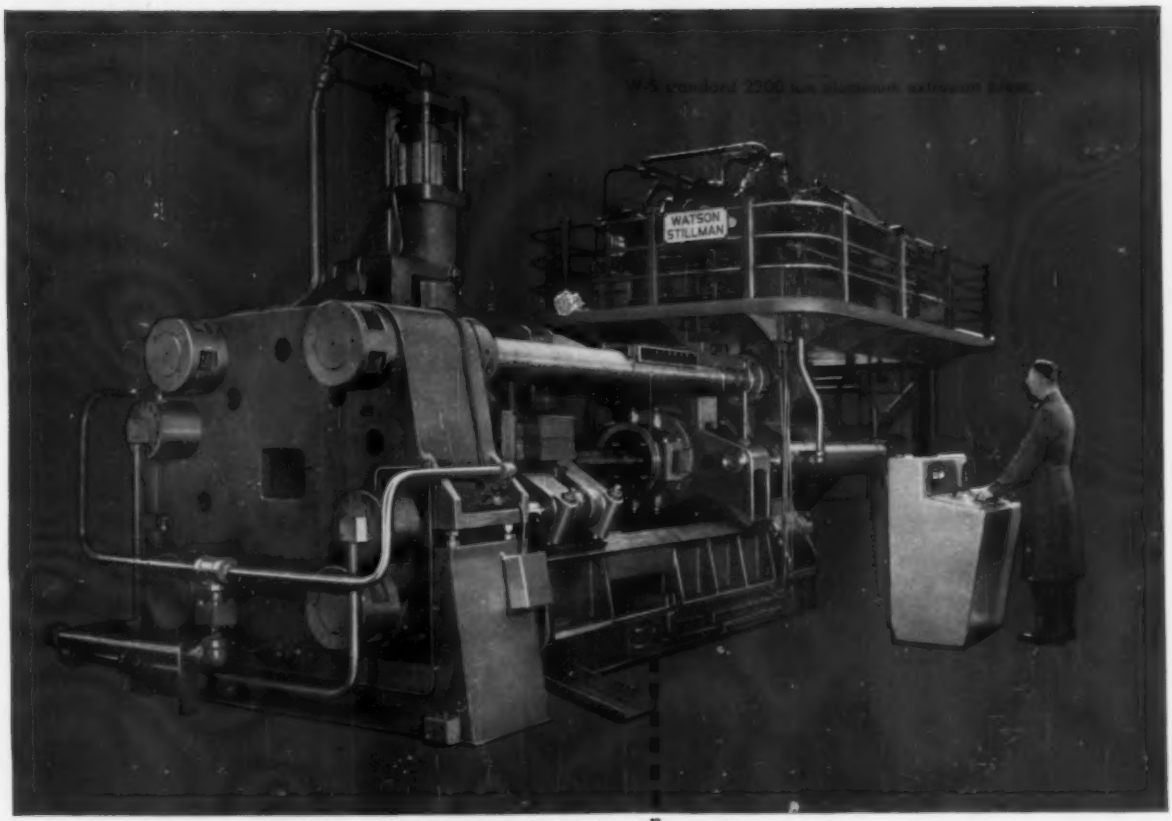
After transformation is complete, the raw forgings are ordinarily reheated above the critical temperature to produce grain refinement. They are then cooled again at a controlled rate and soaked at the suitable transformation temperature. Next the forgings are reheated to the desired tempering temperature for softening and to minimize residual stresses.

A number of different alloy steels have been used for large open-die forgings. Preferences and prejudices are easy to satisfy because the forgings are ordinarily made from ingots cast to order for the specific job. Chemical composition and methods of cooling are important and interrelated because even the smaller sections approach the critical diameter for hardenability. Some method of evaluating the effects of variations in composition and heat treating practices on toughness is desirable because brittle failure is so serious in large components. The most common criterion for judging the resistance to brittle fracture of forgings is the ductile-to-brittle transition temperature in notched-bar tests. Other methods have been tried but none seem to give all of the information desired.

Before the war, most large forgings were used in the normalized condition although die blocks, gun barrels and steel mill rolls were quenched and tempered. The war accelerated the interest in using steels leaner in alloying elements and in investigating techniques for liquid quenching. The importance of producing good notched bar properties is responsible for much of the current attention to quenching practices. Quenched structures usually have better toughness. Enough alloy must be present in large forgings which are quenched to martensitic or bainitic microstructures to give adequate hardenability for the section size and quenching rate involved. Mechanical agitation of the quenching bath is desirable because it avoids the formation of vapor pockets on the work. Refrigeration of the quenching fluid enhances the cooling power of the bath and is usually beneficial. It is considered good practice to quench the bore of hollow forgings. The use of this technique for gun barrels permits a more severe quench without cracking and induces desirable compressive stresses on the bore surface. Procedures have been developed for quenching large forgings of Cr-Mo and Cr-Ni-Mo steel.

High residual stresses are often undesirable in forgings because they can cause distortion during machining or in service. Stress-relief in service is undesirable because it is accompanied by distortion which destroys the designed clearances between stationary and rotating parts.

(*Cont. on p.* 142)



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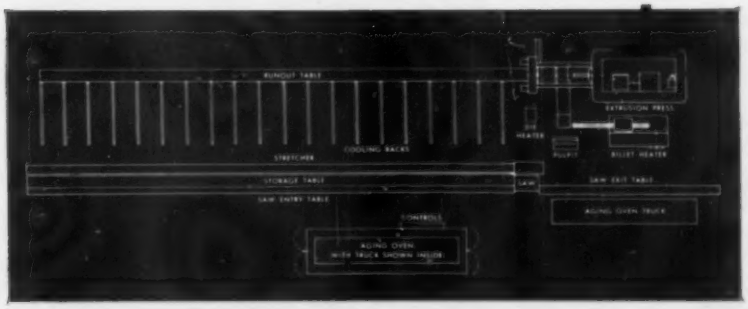

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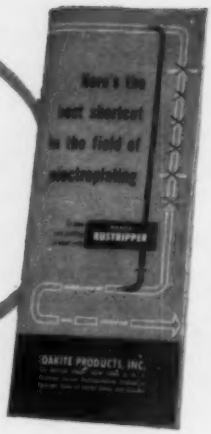
Platers find many uses for chelating* cleaner



*Chelating (pronounced key-lating) cleaners convert metallic salts and oxides into compounds soluble in water.

By chelating and removing rust or heat scale at the same time that it removes oil, Oakite Rustripper combines pickling and alkaline cleaning into one operation. It also avoids disadvantages of acid pickling, such as hydrogen embrittlement and etching of machined surfaces.

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CALIFORNIA: "Rustripper has ended pickling damage such as embrittlement." (Removing oil and light rust from machined landing gears before cadmium plating.)

NEW YORK: "Now saving about $10.40 per day on removing rust and scale and producing brighter plate." (Rustripper, added to reverse current cleaner in automatic plating machine, has eliminated separate pickling of wire towel racks before nickel and chrome plating.)

INDIANA: "Rustripper is the best barrel compound we ever used for this job." (Removing tough heat treat scale from steel screws.) "Total cleaning and zinc plating time has been cut in half."

NEW JERSEY: "Only two cleaning rejects in first 15,000 parts plated." (After Rustripper was added to reverse current cleaner in automatic plater to eliminate smut from tubular steel furniture.)

NEW YORK: "Had trouble with light rust on business machine parts before cadmium plating; also with smut left after electrocleaning. Rustripper cured both troubles."

FREE A 14-page illustrated booklet called *"Here's the best shortcut in the field of electroplating"* tells about many ways in which Oakite Rustripper can be of great value in the plating shop. Write to Oakite Products, Inc., 26H Rector St., New York 6, N. Y.

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Forging . . .

Dimensional and microstructural stability can be insured by proper heat treatment. Aside from the obvious expedient of cooling slowly from the final tempering treatment other precautions have been found helpful. One precaution recommended involves cooling after each normalizing or quenching heat to a temperature suitable for the forging, and holding long enough to insure complete transformation before reheating. It is also desirable to use tempering temperatures low enough to avoid the formation of unstable, spheroidal carbides. For best stability, it is necessary to use stress-relieving heat treatments after machining operations. F. W. BOULGER

New Mechanism Suggested for Ingot Cracks

Digest of "Ingot Cracks Resulting From Impurities in Steel", by P. Bjornson and H. Nathorst, *Jernkontorets Annaler*, Vol. 139, 1955, p. 412-438.

THE PRESENCE of copper and tin in steel impairs its hot working properties. A reason advanced for this is that iron is preferentially oxidized at the atmosphere-metal interface, resulting in a concentration of the tin and copper at the surface. Under the action of a tensile stress at an elevated temperature these metals then penetrate into the austenitic grain boundaries.

In the present investigation an alternative explanation is given for this type of cracking. Longitudinal cracks were observed in basic electric steel ingots 11 in. in section, with 0.30, 0.70, and 0.80% carbon. The cracking was found to be present only in ingots of steel with high copper and tin contents in the range 0.50 to 0.68% copper and 0.016 to 0.32% tin, and occurred when the ingot skin was at 500 to 600° C. (930 to 1110° F.) The cracks generally formed in the middle of one of the faces of the ingot and then spread to the top and bottom of the ingot; their path was found to be intergranular. Micro-analysis of the ferrite film at the grain boundaries

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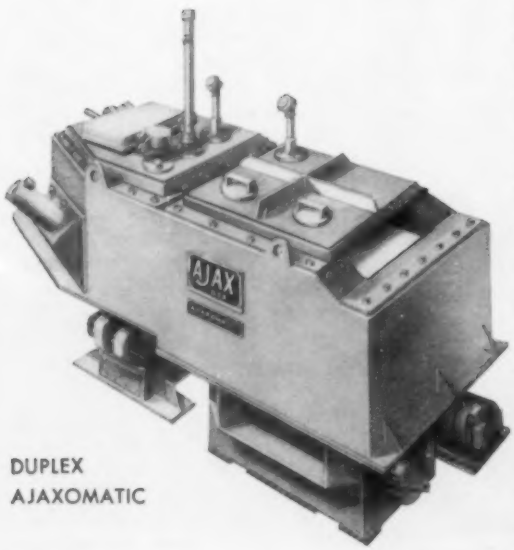

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Ingot Cracks . . .

of the steel showed that the copper and tin contents were considerably greater than the average for the steel. Lattice parameter measurements and examination showed that the ferrite film was a binary eutectic of ferrite and a copper-tin phase. The cooling and transformation stresses caused fracture along planes of the ferrite which had become embrittled by this eutectic.

W. A. MORGAN

Temperature Measurement

Digest of "Recent Developments in Temperature Measurement and Control", by T. Land, Institute of Metals, *Metallurgical Reviews*, 1956, Vol. 1, Part 2, p. 271-288.

THIS REVIEW is written primarily for the metallurgist who would like to increase his knowledge of recent developments in temperature measurement. The presentation is so arranged that it can be studied with three levels of concentration. First, if the reader has only a few minutes to spare, he can look at the photographs and their captions and learn a good deal about new methods and ideas. Secondly, the available methods of measurement are summarized in three tables. Finally, a full discussion is given in the text.

New Thermocouple Materials—Metallurgists now melt and sinter metals at very high temperatures, and the demand has therefore risen for better high-temperature thermocouples. The need first arose, when attempts were made to measure liquid steel temperatures. It was found that the platinum/platinum-rhodium thermocouple could be reused repeatedly at temperatures above 3100° F. if readings are made quickly and the thermocouple is protected from contamination. For temperatures around 3360° F. the older tungsten-molybdenum thermocouples are being replaced by alloys of platinum with 20% and 40% rhodium respectively. The temperature limit for this couple is the melting point of the 20% rhodium wire (3420° F.). The wires are ductile

(*Cont. on p.* 148)

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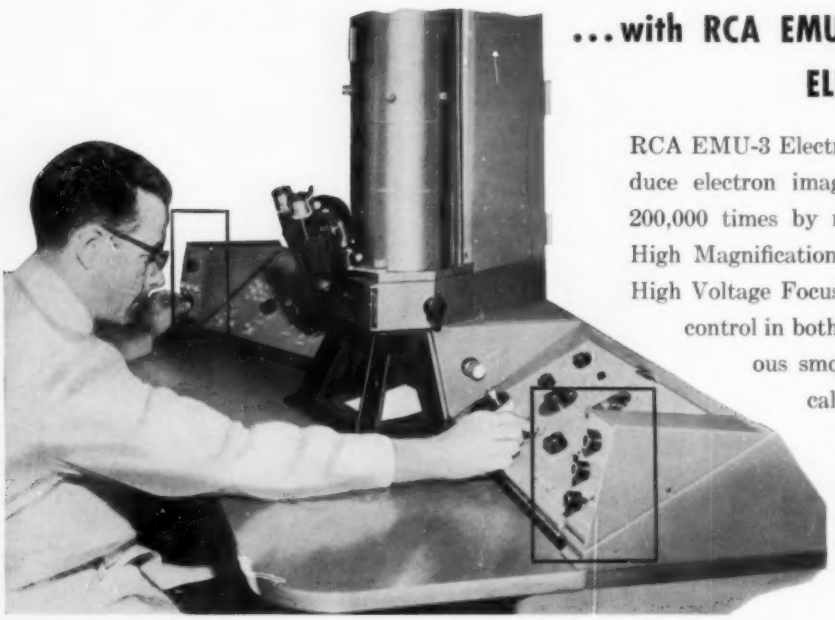

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Tool Steel Topics

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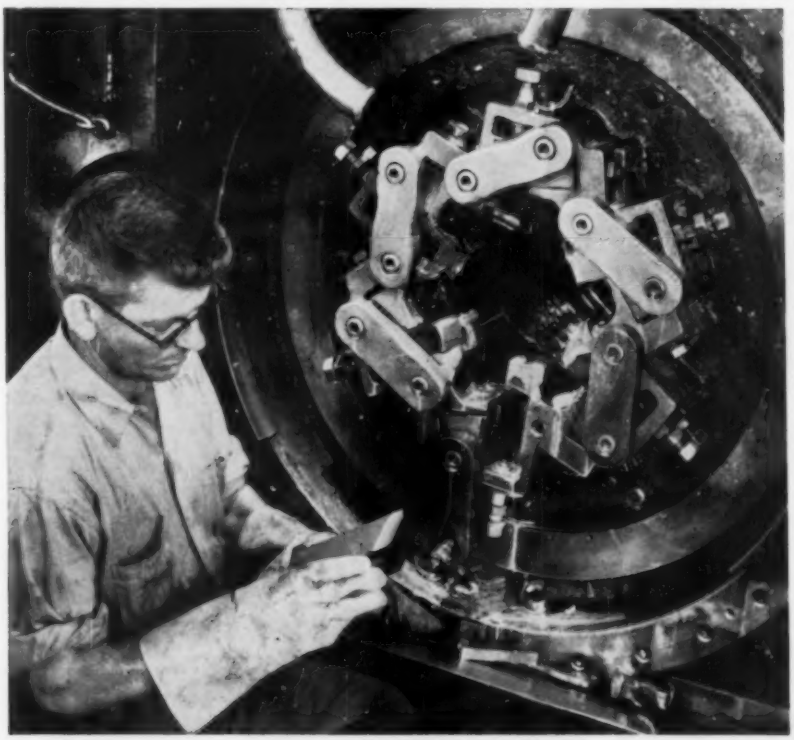


Nickel Billets Get Close Shave with Tools of 66 High-Speed

Biting into billets, castings or forgings of nickel or nickel alloy is one of the toughest assignments ever devised for tool steel. And yet, such jobs are taken in stride with Bethlehem high-speed tool steel at the plant of International Nickel Co., Huntington, W. Va.

Bar peeler cutters, made of 66 High-Speed tool steel, prepare nickel surface for extrusion.

The bar peeler cutters, in the picture above, are hardened to Rockwell C 60-62, and are used in the surface preparation of nickel billets, prior to extrusion. Despite this extremely rugged operation, the cutters are doing an outstanding job, because of their unusual resistance to shock and wear.

66 High-Speed is ideal for all types of cutting applications because of its well-rounded 6-5-4-2 analysis. In addition to its outstanding shock and wear properties, it has excellent red-hardness and abrasion resistance — all the qualities needed for satisfactory high-speed cutting work.

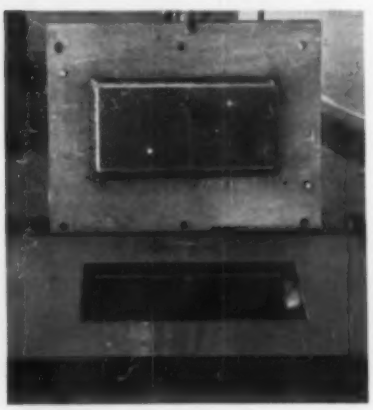
If you would like to learn more about 66 High-Speed, and the many jobs it can handle, simply get in touch with your friendly Bethlehem tool steel distributor.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Overloading of Machines Shortens Tool Life

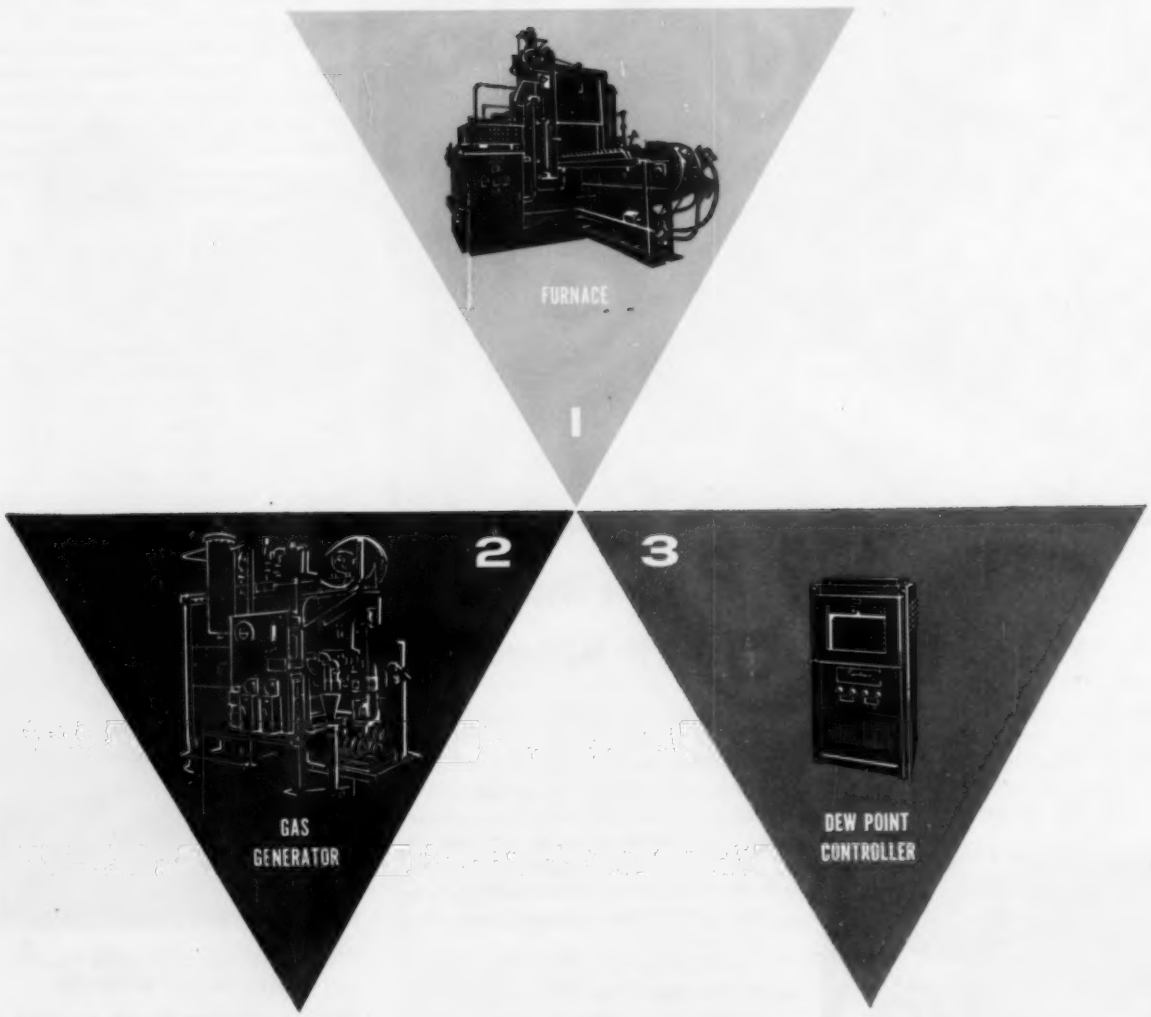
Overloading of machine tools is detrimental not only to the machines, but also to the life of the tools. Overloads cause excessive deflection of the constructional members, which may cause misalignment of mating tools and change calculated clearances. This in turn may produce excessive wear on the tools, and may result in defective parts or premature tool breakage.

Overloading frequently results from performing an excessive number of operations at one time, such as multiple piercing of holes. Overloads of this type can be prevented without changing the work to be done by providing, (1) shear on either the punch or die to reduce the maximum punching load, or, (2) by staggering punch heights so that the multiple operations are performed in sequence, instead of all at the same time.



UP TO 30,000 CONVEYOR PANELS WITH DIE OF 67 CHISEL

This large blanking die was employed in the production of conveyor panels, made from 14-gage sheet steel. It was hardened to Rockwell C-50, and turned out as many as 30,000 pieces before redressing was required. 67 Chisel is our popular chrome-tungsten type of shock-resisting tool steel. In addition to its use in blanking, it's excellent for hot-work tools, shear blades, and swaging dies. Give it a try.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DEW POINT
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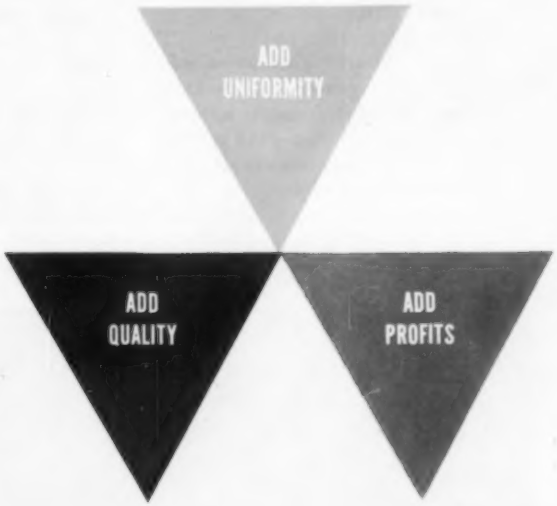

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Liquid Metal Thermocouples—Liquid metal pyrometry has been perhaps the most dramatic achievement in this field during the past 15 years. Platinum/platinum-rhodium thermocouples are protected from the liquid metal by a silica tube so thin that the measurement can be completed in 20 sec. The tube may last for no more than a single immersion but costs only a few cents. A quick-acting recording potentiometer is advisable for such measurements, and special recorders have been developed in which the chart moves only when the temperature of the thermojunction is above 1830° F.

Continuous temperature measurement of liquid nonferrous metals is still difficult because of the deterioration of the thermocouple protective sheaths. A new development for use in molten zinc or aluminum is the introduction of a vitreous-enameled mild steel sheath. Nevertheless, no thoroughly reliable thermocouple sheath for continuous immersion in liquid metal exists at present.

Radiation Pyrometers—The optical pyrometer and the total radiation pyrometer are the best and most convenient radiation instruments for most applications. Several different radiation measuring devices are available for measuring limited regions of the spectrum, and these have been incorporated in pyrometers. All are extremely fast in response.

The first of these is the barrier-layer selenium photocell, which responds to visible radiation. It generates a current which is proportional to incident light; therefore, a cell, a lens and a micro-ammeter are sufficient to measure temperature.

Vacuum photo-emissive cells are also used in pyrometers. They need electronic equipment but can be made more sensitive than the selenium cell: they are used to about 1650° F. The newest type of photoelectric cell is the photoconductive cell, the lead sulphide cell being the most common. It is sensitive up to the limit of transmission of glass and has a peak sensitivity of about 2.6μ. It can be used to measure temperatures as low as 300° F.

An interesting new pyrometer has been developed at the National Physical Laboratory (British) which extends the range of the optical pyrometer by the application of the "image converter", a device that allows infrared images to be seen. The infrared image falls on a special cathode in an evacuated tube and releases electrons; the electrons are accelerated and strike a phosphorescent screen forming a visible image. The device permits readings to be taken with an optical pyrometer at temperatures well below red heat.

A new surface pyrometer has been designed to measure, not the emitted radiation, but the full blackbody radiation which comes from any opaque body. This pyrometer therefore measures true temperatures and is nearly independent of the emissivity of the surface. In

(*Continued on page* 150)

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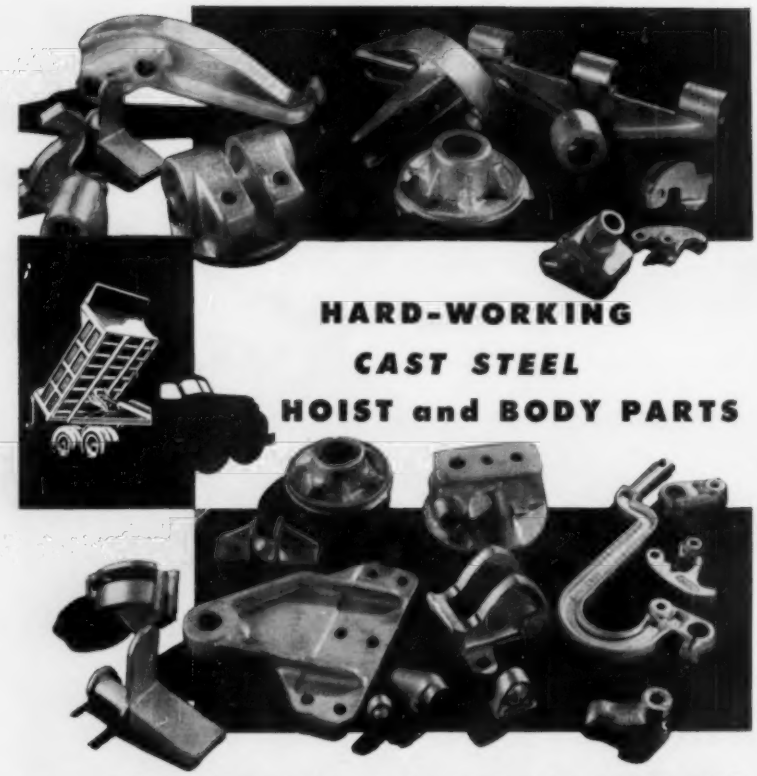

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Temperature . . .

operation a hemispherical gold reflector is placed on the hot surface. The cavity within the hemisphere is then surrounded by the hot surface and its reflection in the gold mirror. This is equivalent to a black-body enclosure. A small fluorite window is provided at the apex of the hemisphere. Black-body radiation at the surface temperature passes through the window and falls on a thermopile. The true temperature is recorded directly. This new surface pyrometer may be used to take quick readings (about 5 sec.) but it is not yet available for continuous measurement. The temperature range is 120 to 2375° F.

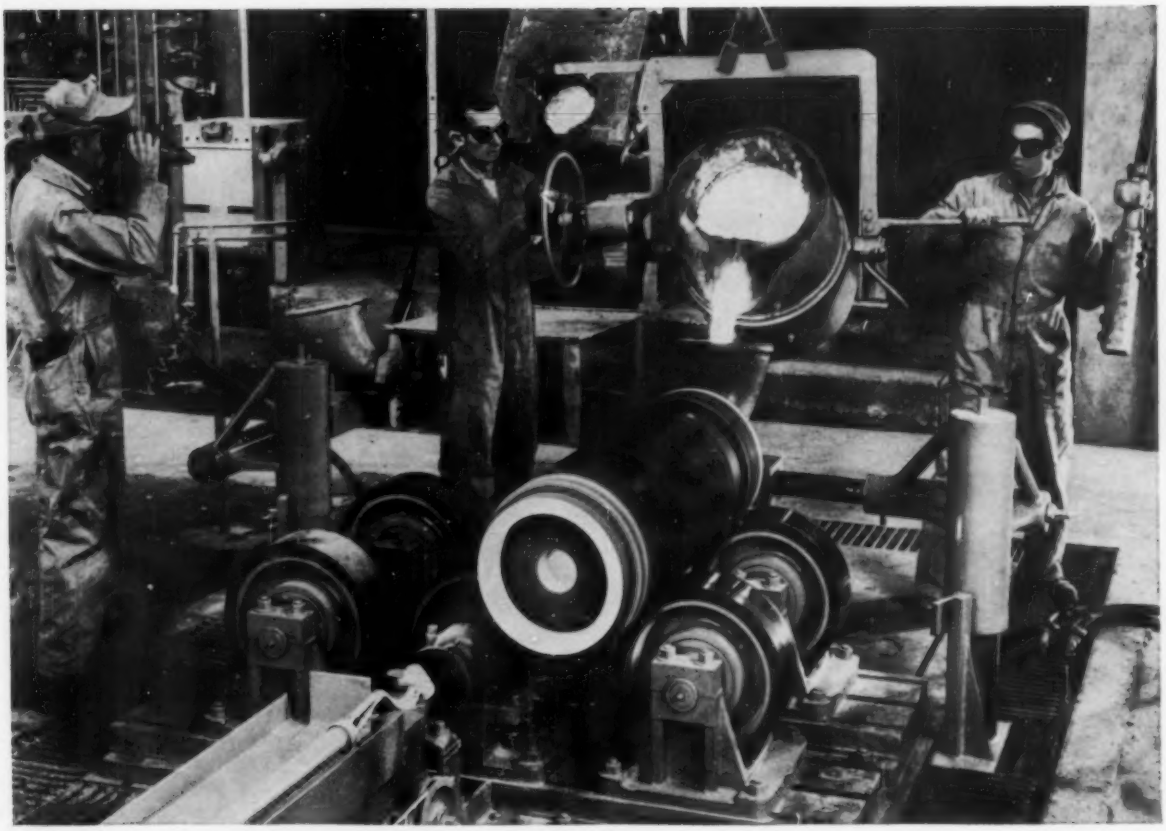
Automatic Control – Proportional control devices are much more precise than on-off control, but they are not quite perfect. In most proportional control equipment every position of the fuel valve corresponds to a particular error in temperature. Only one valve position corresponds to zero error. If the furnace needs more fuel, the controller allows the temperature to drop a little so that the fuel valve opens. This small temperature error remains as long as extra fuel is needed.

This "droop" can be avoided. The error in temperature can be made to cause a corresponding rate of change of the valve position. The fuel valve will then remain at rest at any position provided that the temperature error is zero. The valve position is proportional to the time integral of the temperature error; this mode of control is called the integral control. It avoids "droop" but is slow in operation.

The advantages of proportional and integral control may be combined. The valve position is made proportional to the sum of the temperature error and its time integral; that is, proportional plus integral control. This is adequate for most applications.

Some jobs will occur, however, need further refinement. A third term, proportional to the rate of change of the temperature error may be added to the movement of the valve. The function of this derivative term is to stabilize control systems, to prevent overshoot, and make the response of the controller

(*Cont. on p.* 152)



WHY GOOD CENTRIFUGAL CASTING DEMANDS INDUCTION MELTING

Though centrifugal casting has values apart from any melting furnace used, it achieves its ultimate performance only with induction melted metals. You may have wondered yourself why the vast majority of critical centrifugal castings are poured from Ajax-Northrup induction furnaces. The reasons are many—

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The precise metal temperature control available with Ajax-Northrup induction equipment is another important consideration in the production of consistently uniform castings. Hot and cold pours are eliminated. And this combination of ideal temperature control and perfect mixing adds up to good, reproducible results.

Ajax-Northrup induction melting equipment, with its unique control system offers you maximum melting efficiency with resulting lower melting costs. The new compact designs incorporate many features which minimize floor space requirements, drastically reduce installation costs, minimize maintenance, and provide simple, more efficient operation.

Induction heating & melting

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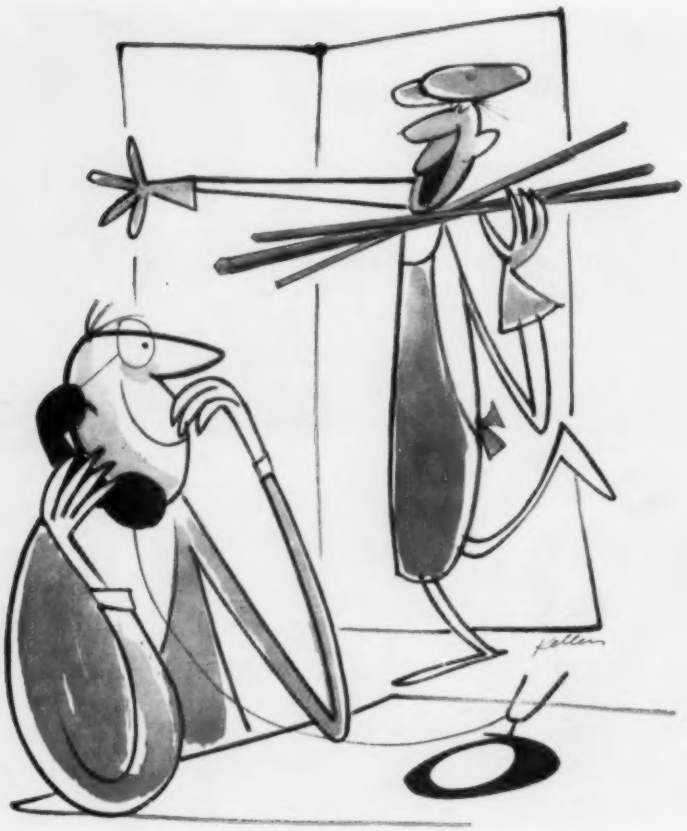

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Temperature . . .

faster. We thus arrive at the "three-term proportional control system". With proportional, integral, and derivative action this flexible system will give accurate control of temperature even under difficult conditions. It is a great improvement on the simple on-off method, and is being used on many of the newer temperature controlled furnaces.

Electronic computers may play an important part in temperature control in the future. Information about temperature and the other conditions subject to control could be fed into a computer. From the numerous signals fed into it the computer would calculate the alteration to be made, either to the positions of valve or the setting of controllers. Electronic computers are usually digital devices. The information fed to them must therefore be converted into numbers and if the numbers are in the scale of 2 instead of the usual scale of 10 their transmission is greatly simplified. Devices are therefore being produced which will convert the deflection of a pointer into a series of impulses representing any number coded in the scale of 2. This development is as yet very new but it may well have many interesting applications during the next decade.

W. W. AUSTIN

Wedge Welding of Unlike Metals

Digest of "Technique and Application of Wedge Welding", by Wilhelm Hoffmann, *Ciencia y Técnica de la Soldadura*, No. 33, November-December 1956, p. 1-4.

SEVERAL YEARS AGO the author investigated the possibility of joining aluminum to copper by means of wedge welding. This type of joint has since been adopted by aluminum electrolysis plants where it has replaced the old screw-type joints. The welding is done in the following manner: An aluminum bar and a copper bar are heated in a furnace to a temperature which lies between the melting points of aluminum (1220° F.) and the aluminum copper eutetic (1020° F.). When the

(*Cont. on p.* 158)

DREVER

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Drever's 20-KW furnace and ammonia dissociator are ideally suited for use in laboratories where ruggedness of construction and reliability of operation are essential. The electric furnace is heated by ceramic resistor bar units and is equipped with an alloy muffle designed for and capable of operating at a maximum temperature of 2150°F.

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Shown is a Drever 20-KW Alloy muffle furnace used for sintering in the Powder Metal Research Laboratory of F. J. Stokes Corporation, Philadelphia 20, Pa. Located over the furnace is a 150 CFH Ammonia Dissociator providing atmosphere to the furnace.

DREVER COMPANY

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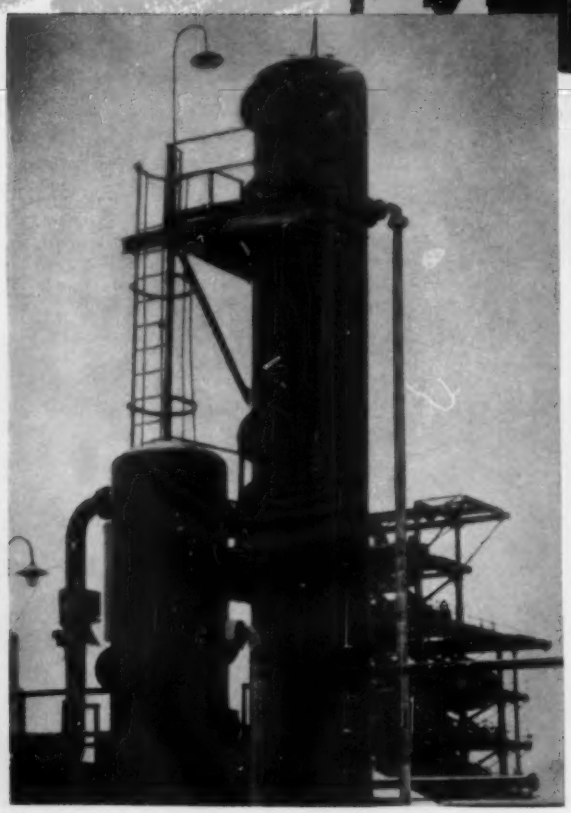
39

HAYNES Alloys solve the *tough*



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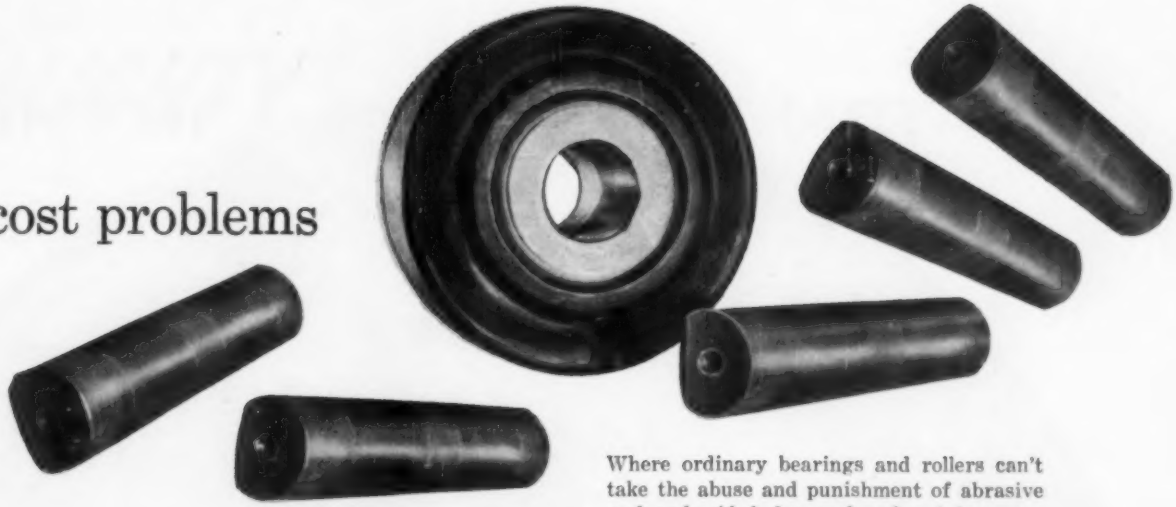

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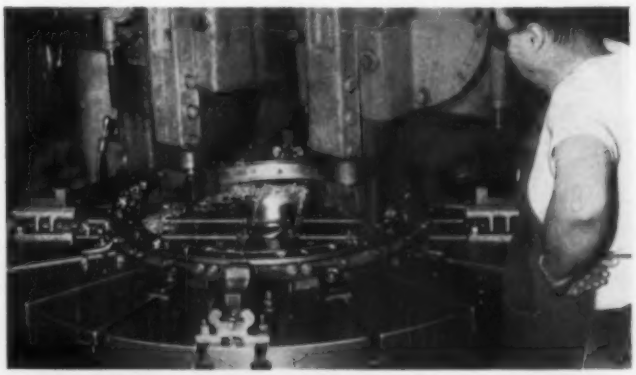

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IN THIS

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METAL PROGRESS

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Wedge Welding . . .

welding temperature is reached the wedge-shaped end of the copper bar is placed against the flat end-surface of the aluminum in a heated die. The bars are slowly squeezed together by a screw press. The joint is not affected by the oxidation of the copper because a eutectic fluid forms in the contact zone and diffuses through the aluminum and copper. The excess fluid is squeezed out and flows away carrying the oxides with it. Pressure is maintained until the eutectic solidifies so that the eutectic zone will be kept to a minimum. Test pieces subjected to tensile tests always failed in the aluminum.

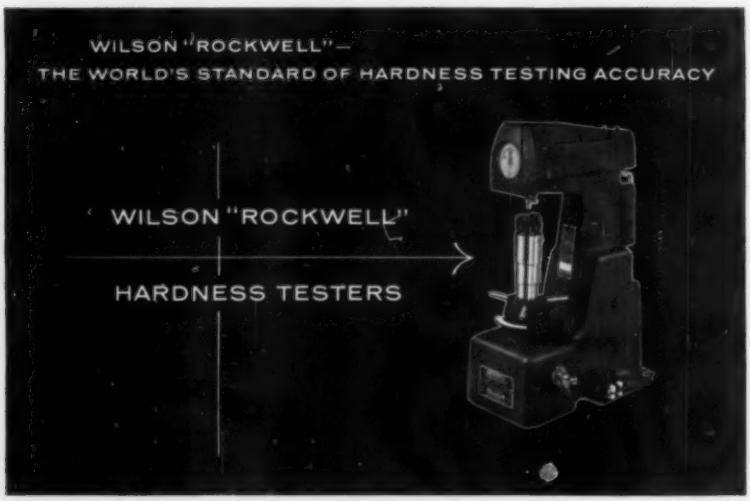
Copper and aluminum are also wedge welded at temperatures below 1020° F. without forming a eutectic fluid. In this instance the copper is protected against oxidation either by plating it with silver or by working in a pure nitrogen atmosphere. This method requires greater pressures.

In joining aluminum to steel, the steel must be protected against oxidation either by plating it with silver or zinc or by hot galvanizing the cone which constitutes the wedge. The parts are heated in the same mold in which welding takes place.

Zinc-plated steel cones can be joined to aluminum at 790° F., since the melting point of the zinc-aluminum eutectic is 715° F.

Tensile tests of aluminum-steel samples resulted in failure in the aluminum. However, when fracture in the aluminum was prevented by a special apparatus, failure occurred in the steel and not in the aluminum-steel transition zone. The tensile strength was about 8000 psi.

BERNARD TROCK



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Nature of Oxides on Stainless Alloys

Digest of "Structure of Oxides Formed on High-Temperature Alloys at 1500° F.", by John F. Radavich, A.S.T.M. Special Technical Publication No. 171, 1955, p. 14-31.

THE high temperature resistance of iron-nickel-chromium alloys is largely determined by the structural, chemical and physical nature of the surface oxides formed. The author has studied the characteristics of the oxides present on seven alloys after exposure to 1500° F., with and without applied stress.

The materials examined were **N-155, Hastelloy C, 19-9 DL, 17-14** (Cu-Mo), Type 347, Type 310 and Type 316 (Cb) alloys. Electron microscopy, electron diffraction, and X-ray diffraction techniques were employed. In addition macrographs of the stress-ruptured specimens were made.

The large cracks visible in the oxide extended into the base metal, but many small cracks were found in the latter which were not present in the scale. In general, the number of cracks in the metal and in the oxide corresponded, and some correlation with the stress-rupture life was found for alloys tested in the same stress range.

The scale formed during stress-rupture tests showed a definite rhombohedral α Fe_2O_3 phase in all of the austenitic alloys except Type 310, which contained a large amount of Cr_2O_3, possibly due to the higher chromium content. A small amount of spinel phase with different lattice parameters was also present, with or without NiO and Cr_2O_3 in solid solution with α Fe_2O_3. The NiO was

(*Cont. on p.* 160)

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Oxides . . .

the main component of the Hastelloy scale, whereas the N-155 alloy showed a predominant amount of spinel phase of lattice parameter 8.38 kX (1kX unit = 1.00202 A).

Specimens which were exposed to 1500° F. without stress for times corresponding to those of the stress-rupture tests gave similar results with the exception of the 19-9 DL alloy. In this instance a large amount of Cr_2O_3 was observed instead of α Fe_2O_3, the spinel parameter was higher, and there was no Cr_2O_3 solid solution. The scale was nonadherent and revealed a temper-color film underneath, which consisted of three layers – a thin substrata, a thick opaque layer, and a smooth glassy structure. The thin portion contained Cr_2O_3 solid solution with some spinel of 8.38kX lattice parameter; the thicker portion contained a spinel of 8.38 kX lattice parameter and an unknown material; and the glassy layer was believed to be amorphous silica.

Other specimens were subjected to 5-min. oxidation at 1500° F. without stress, and gave oxide films which corresponded quite closely to the scales previously examined, except that α Fe_2O_3 replaced Cr_2O_3 in the film on Type 310 alloy. Only the spinel of lattice parameter 8.38 kX was observed throughout. Tilted electron diffraction analysis indicated that the oxide films of 19-9 DL, Type 17-14, and Hastelloy C alloys were oriented with the (111) planes of the sesquioxide phase parallel to the surface. In the Type 347 alloy, the spinel phase was oriented with the (222) planes.

Optical photomicrographs and electron microscope replicas of the oxide film after 5-min. exposure show the oxide growth with respect to inclusions, grain boundaries, and matrix, while electron microscope photographs of the stripped film provide direct evidence of the structure.

The authors conclude that amorphous silica may be associated with the thin oxide film adjacent to the metal, and may be a more effective healing agent than the oxide scale or film. The presence of a continuous amorphous silica layer has previously been demonstrated on austenitic and ferritic stainless steels at 1500° F.

R. C. A. THURSTON

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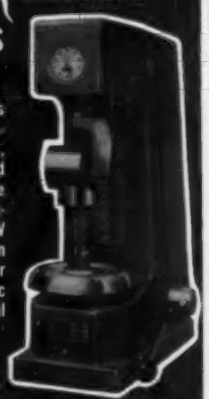

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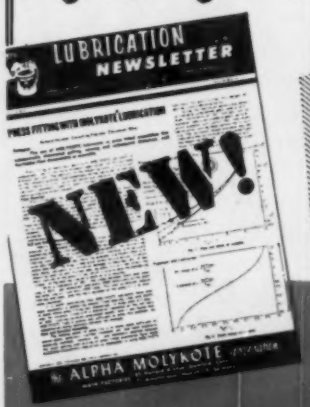
LIST NO. 131 ON INFO-COUPON PAGE 170

Engineering Data on MOLYKOTE® lubricants



- Being published regularly
- Every issue features a full-length technical article on the use of MOLYKOTE Lubricants in industry.
- "How-to" stories on tough lubrication applications.
- Get on our mailing list TODAY. Write to

The ALPHA MOLYKOTE CORPORATION

Main Factories:
65 Harvard Avenue, Stamford, Conn.
71 Arnulfstrasse, Munich 19, Germany

LIST NO. 110 ON INFO-COUPON PAGE 170

HARDNESS TESTING SHORE SCLEROSCOPE

Pioneer American Standard Since 1907

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

OVER 40,000 IN USE

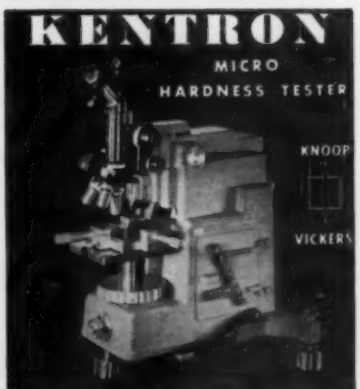
SHORE INSTRUMENT & MFG. CO., INC.

90-35M Van Wyck Exp., Jamaica 35, N.Y.

LIST NO. 133 ON INFO-COUPON PAGE 170

KENTRON

MICRO HARDNESS TESTER



Applies 1 to 10,000 gram loads

Write for Bulletin

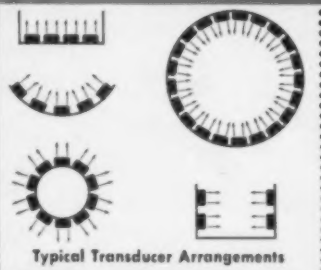
Kent Cliff Laboratories Div.

The Torsion Balance Company

CLIFTON NEW JERSEY

LIST NO. 53 ON INFO-COUPON PAGE 170

ULTRASONIC CLEANING



Typical Transducer Arrangements

SONOGEN®

Ultrasonic-Power Generators with hermetically-sealed barium-titanate Transducers — 40Kc/sec.

Transducer Radiating Areas of ¼ sq. ft. to 10 sq. ft. — for use in solvents and detergents.

Eliminates hand operations — Reduces rejects in plating, finishing, assembly.

For washing, degreasing, removal of buffing compounds, radioactive contamination, soldering flux, plaster, carbon smut, etc.

Literature upon request.

BRANSON ULTRASONIC CORP.

Specializing in Ultrasonics Since 1946

6 BROWN HOUSE RD., STAMFORD, CONNECTICUT

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WELDCO

FABRICATED MONEL PICKLING EQUIPMENT

• Hairpin Hooks • Sheet Crates

• Steam Jets • Chain

• Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.

3721 OAKWOOD AVE. . . . YOUNGSTOWN, OHIO

LIST NO. 94 ON INFO-COUPON PAGE 170

CIRCO

Since 1923

Specialists in All Phases of METAL CLEANING EQUIPMENT

- DEGREASERS • AGITATING WASHERS • PICKLERS
- PHOSPHATIZING WASHERS • ALKALINE WASHERS
- FLOW COATING SYSTEMS • "SPOTLESS" DRYERS
- OVENS • ULTRASONIC CLEANING EQUIPMENT

We will be happy to send a sales engineer to help you with any metal cleaning equipment problem. Complete information on request.

- ***CIRCO-SOLV** (Trichlorethylene)*
- ***PER-SOLV** (Perchlorethylene)*

CIRCO EQUIPMENT COMPANY

51 Terminal Avenue, Clark, New Jersey • Fulton 8-8600

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Is

PM²·X

your answer?

GOLD

Binary ALLOYS

Doped ALLOYS

Tertiary ALLOYS

Eutectic ALLOYS

Let X equal your problem in electronics or atomics. Technic experience is that application of PM² (Precious Metal Plating Metallurgy) may be your solution.

ALLOY GOLD PLATING

Growing complexity of requirements in the electronic and atomic fields brings demand for gold coatings that have qualities other than 24K gold. Technic methods and equipment enable you to meet problems with a new tool — an exact metallurgy which alloys 24K plating gold with trace amounts, or more, of desired elements.

TECHNIC SERVICE

We engineer and install all your requirements for precious metal electroplating with rigid scientific control. And our specialists are *your* specialists until your installation achieves optimum performance. Send us your problems — old or new — for Technic recommendations.

PM² *Write, wire or call.*

683-T

TECHNIC, INC.

39 Snow Street,
Providence, R. I.
JAckson 1-4200
Chicago Office—7001
North Clark Street

THE LARGEST ENTERPRISE OF ITS KIND IN THE WORLD

LIST NO. 124 ON INFO-COUPON PAGE 170

Sel-Rex®

PRECIOUS METALS FOR INDUSTRIAL PLATING

BRIGHT GOLD

Mirror-bright finish in any thickness directly from the bath. Patented

PUR-A-SALTS

Restores contaminated cyanide plating baths to full, trouble-free operation. Patented

SILVREX BRIGHT SILVER

Crystal-clear solution that produces mirror-bright deposits. Patented

SILVER SOL-U-SALT

Non-dusting—safest and easiest to use.

BRIGHT RHODIUM

Brilliant, fine-grained non-tarnishing deposits.

RHODEX

Only rhodium electroplating process that yields extra heavy compressively stressed deposits. Patent Pending

ACID GOLD PLATING PROCESS

Developed specifically for plating printed circuits. Mildly acid so that neither the laminate nor the adhesive at the inter-face of printed circuit boards are affected during the plating process.

Complete installation and servicing on all precious metals processes.

SEL-REX CORPORATION

Dept. BB, Nutley 10, New Jersey

Offices: Detroit—Chicago—Los Angeles

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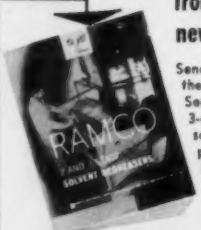
Q A METAL PARTS CLEANING PROBLEMS?

Get the answers RIGHT from RAMCO'S new BULLETIN!



Send for your copy of the Ramco Bulletin. See how Ramco 2- and 3-dip degreasers can solve your metal parts cleaning problems safely, efficiently, economically! Send today!

RAMCO EQUIPMENT CORP.
DIV. OF RANDALL MFG. CO., INC.
809 Edgewater Rd., New York 39, N.Y.

LIST NO. 128 ON INFO-COUPON PAGE 170

How Roll Coater

Pre-Painted

METAL SAVED MONEY AND IMPROVED QUALITY ON

R-C-000 LICENSE PLATES

PROBLEM:

Stello Products Company, Logansport, Indiana, manufacturer of tags, license and "booster" plates, had the problem of excessive direct labor charges. In the previous expensive method of making these items, plates had to be stamped from bare metal—and then cleaned individually—and spray painted on both sides. This method did not give the uniform quality demanded—and Stello turned to Roll Coater for a solution.

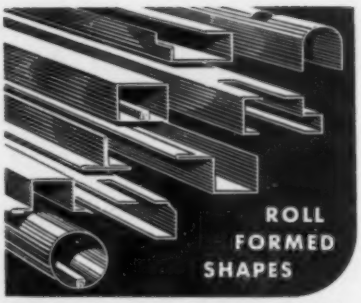
SOLUTION:

Roll-coated metal was tested by Stello Products Company. *Pre-painted* and *baked* on both sides, this metal eliminated *entirely* the cleaning and spray painting operations—withstood rigorous stamping tests—and relieved painting facilities for other jobs. Says J. C. Cotner, president of Stello Products Company, "Roll Coater metal is now saving us approximately 50% in direct labor costs—and is giving us the desired uniform quality in our plate production. It really solves our problem."

SEND FOR FREE BROCHURE and SAMPLE TODAY!

Roll Coater
INCORPORATED
PENDLETON INDIANA

LIST NO. 155 ON INFO-COUPON PAGE 170



Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO

LIST NO. 101 ON INFO-COUPON PAGE 170

STEEL FABRICATED and RUBBER-LINED TANKS for the Plating Industry

ARco

- Plating tanks any size or shape fabricated and rubber-lined to your specifications. A complete service from basic design to installation, also fabricated and rubber-lined pipe and fittings. Write Dept. "MP" for complete details.

Subsid. of Automotive Rubber Co., Inc.

ARco STEEL FABRICATORS • INC.
12542 BEECH ROAD • DETROIT 39, MICH.

LIST NO. 153 ON INFO-COUPON PAGE 170

RUST-LICK IN AQUEOUS SYSTEMS

Grade "C-W-25"

Non-flammable
Non-toxic
Aqueous Oily Film
Protects Ferrous Parts for Long Periods Indoor Storage

Write for free sample and brochure
Specify Grade "C-W-25"

PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS.

LIST NO. 121 ON INFO-COUPON PAGE 170

NEW...

STANDARD REFERENCE

For Superior Metal Treating and Finishing Products.

Send for your free copy of "ONE SOURCE" now!

JOHN Swift

CHEMICAL COMPANY INC.

Canton, Connecticut

LIST NO. 92 ON INFO-COUPON PAGE 170

the GRIES

MICRO-REFLEX

HARDNESS TESTER

Loads: 10 to 3000 gram with CARL ZEISS Optical System

Measurements: to 0.0001 mm. . . . Observations on Ground Glass . . . Projection: to 0.001 mm. . . . Many Unique, Very Important Features.

INVESTIGATE!

Write for Bulletin No. A-16

GRIES INDUSTRIES, INC.

Testing Machines Division

NEW ROCHELLE 3, N.Y.

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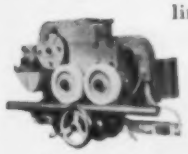
MARKING for any product!

Rubber type, logos and dies . . . imprinting units for rounds or sheets . . . for in-line marking of moving stock.



Steel stamps, dies and machines for marking round, flat or contoured products . . . production marking machines for high-speed automatic lines.

Write for information and literature—indicating product to be marked.

JAS. H. MATTHEWS & CO.

Over 100 Years of Service to Industry

3967 FORBES ST. • PITTSBURGH 13, PA.

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A CABLE SPLICED IN 10 SECONDS!

ERICO PRODUCTS, INC.

Complete Arc Welding Accessories

2070 E. 61st Place, Cleveland 3, Ohio

Write for Caddy Catalog

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make hardness tests ANYWHERE WITH THE NEWAGE TESTER

- CLAMPS, JAWS & BASE PLATE ARE ELIMINATED
- NO CONVERSIONS OR CALCULATIONS
- TEST ANY SIZE, SHAPE OR TYPE METAL
- NO SKILL REQUIRED
- SCALE READINGS IN ROCKWELL & BRINELL
- ACCURACY GUARANTEED

Many thousands used by industry and government. Write, wire or call for additional details and prices.

NEWAGE INDUSTRIES, INC.

222 York Road, TUrner 4-8094, Jamestown, Pennsylvania, Dept. MP

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Automatic Welding . . .

- All Analyses
- Coated, Straightened
- Cut • Coiled and Spooled

Ask the Man Who KNOWS Stainless Welding . . .

Call Mr. Electrode . . . His years of experience and leadership in providing the *correct*—

Stainless and Heat Resistant Arc Welding Electrodes

—place a trusted guarantee back of your welding operations.

MAURATH, INC.

21830 Miles Avenue • North Randall 22, Ohio

Phone: MOntrose 2-6100

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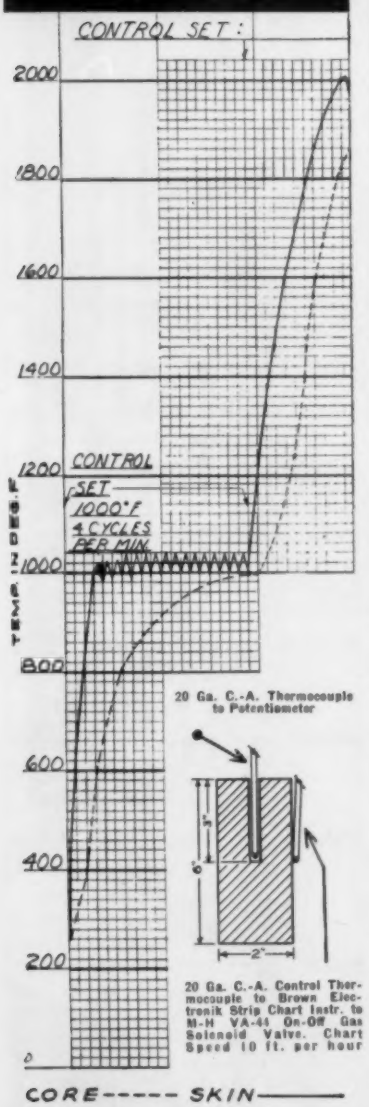
Instantaneous Heat!

Firing Rate: 50,000 B.T.U. Per Sq. Ft.
Blower Air = 117 C.F.M.



INSPECT THIS PROVEN COMBUSTION SYSTEM

THE A. F. HOLDEN COMPANY
14341 Schaefer Highway
DETROIT • MICHIGAN

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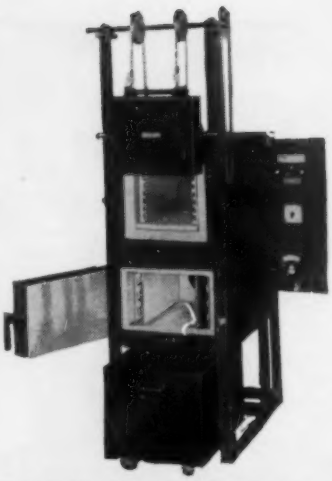


SAVE SPACE WITH A

SERIES 8055
COMBINATION MODEL

Two independent furnaces (hardening and drawing) in the same floor space one requires. Complete with independent controls. Hardening furnace available in both a 2000° and a 2300° F. range.

Drawing furnace has a maximum of 800° F.* Quench tank included with the exception of the largest standard model.

Model	Chamber Size H.	W.	L.	Prices 2000° F.	2300° F.
8055 A	6"	6"	12"	$ 865.00	$ 975.00
8055 B	9"	9"	18"	1325.00	1450.00
8055 C	12"	12"	24"	1850.00	1950.00
8055 D	18"	18"	36"	2750.00	2875.00

*Also available up to 1250° F.

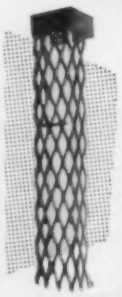
WRITE FOR FREE LITERATURE, SPECIFICATIONS and price list of Lucifer Furnaces in wide range of sizes—top loading and side loading types. Engineering advice without obligation. Write, wire or phone today.

LUCIFER FURNACES, INC.
NESHAMINY 7, PA.
Phone: Diamond 3-0411

LIST NO. 122 ON INFO-COUPON PAGE 170

there's a

Glo-QUARTZ*
IMMERSION HEATER
for
Your Every Heating Requirement



- INSTANT HEATING
- SHOCK-PROOF
- AVAILABLE IN ALL VOLTAGES —WATTAGES, ONE AND THREE PHASE

Available from your Electroplating Distributor

WRITE FOR BULLETIN ▶

Glo-QUARTZ
ELECTRIC HEATER CO., INC., Willoughby, Ohio
*Reg. U. S. Pat. Off. Phone: Willoughby 2-5521

LIST NO. 145 ON INFO-COUPON PAGE 170

RUST-LICK
IN AQUEOUS SYSTEMS

Grade "B"
FERROUS METAL PROCESSING
Eliminates . . .

Rust
Fire Hazards
Toxicity
Dermatitis
Degreasing

Write for free sample and brochure Specify Grade "B"

PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS

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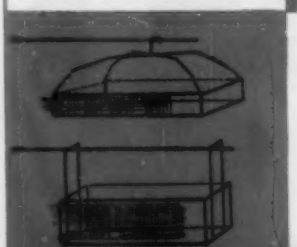
JELLIFF BASKETS



for ALL Industrial Uses

- Degreasing
- Anodizing
- Pickling
- Plating
- Heat Treating
- Heavy Industrial Types

ANY SIZE AND SHAPE • ANY DUCTILE METAL

Ask for Bulletin 28

WIRE PRODUCTS Jelliff SINCE 1860

THE C. O. JELLIFF MANUFACTURING CORP.
SOUTHPORT • CONNECTICUT

LIST NO. 91 ON INFO-COUPON PAGE 170

WIRETEX *fabricated*

PLATE POTS

Last longer.... cut operating costs
fast delivery..low cost

WIRETEX PLATE POTS withstand temperatures up to 2100°! Cut neutral or cyanide bath costs! Last 15 to 20% longer! Operating costs drop 25 to 35%! Down time is almost halved!

- All metals
- I.D. dia. up to 24" and larger
- Depths unlimited
- Dished bottom heads
- Overlapping seams
- Double x-ray quality weld, inside and out
- Heavy steel flanges
- Stress relieved
- Sand-blasted finish

Before you buy any salt pot, or if you have other heat and corrosion resistant problems —SEE WIRETEX.

Before you buy any salt pot, or if you have other heat and corrosion resistant problems—SEE WIRETEX.

Wiretex mfg. co. 5 Mason St., Bridgeport 5, Conn.
Specialists in Processing Carriers Since 1932

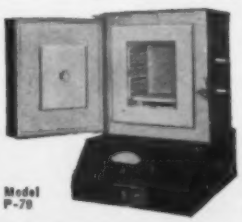
LIST NO. 114 ON INFO-COUPON PAGE 170

PRODUCED AND PRICED RIGHT FOR YOUR ELECTRIC FURNACE NEEDS

DYNA-TROL

MODEL NO.	FIRING CHAMBER (H.W.D.)	PRICE (300° to 2000°)	PRICE (400° to 2300°)
P48	4½"x4½"x8"	$90.00	$110.00
P79	6"x8"x9"	$205.00	$225.00
P918	9"x9"x18"	$480.00	$528.00
P414	14"x14"x14"	$525.00	$603.25
P124	12"x12"x24"	$715.00	$822.25
P818	18"x18"x18"	$775.00	$887.50
P138	18"x18"x30"	$1125.00	$1312.50

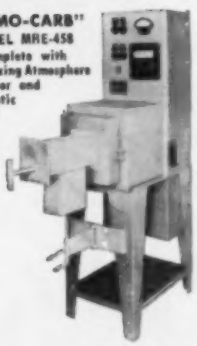
Automatic Controls Available on all Models



Model P-79

- Infinite zone temperature control
- Zone temperature indication by Pyrometer Selector Switch
- Automatic hold and cut-off instrument available
- Patented element holders
- Infinite variety of time-temperature curves obtainable
- Rugged construction

"ATMO-CARB"
MODEL MRE-458
Complete with Carburizing Atmosphere Generator and Automatic Control



$1325.00
Other Sizes and Arrangements Available

MANUFACTURING CO.
Chester 77, Pa.

LIST NO. 138 ON INFO-COUPON PAGE 170

GOOD USED EQUIPMENT AT REAL SAVINGS TO YOU!

In our large, rapidly turning-over stock, we often acquire brand-new items, still in their original crates. We offer these at a fraction of their replacement cost, and with the same guarantee that the original manufacturer gives. Several of our new furnaces are pictured below.

Upton Salt Bath
Hi and Low Heat
Price $1975 Each

Our stock is constantly changing! Before you buy any furnace or accessory, call us collect and let us show you how to save money! (Money-Back Guarantee). We pledge that any unit we advertise is in stock at one of our warehouses at the original time of publication. However, they are subject to prior sale, so act now!

METAL TREATING EQUIPMENT EXCHANGE, INC.
9825 GREELEY ROAD
DETROIT 11, MICHIGAN

LIST NO. 142 ON INFO-COUPON PAGE 170

WANTED

SURPLUS FURNACES

REWARD

WE PAY CASH FOR SURPLUS INDUSTRIAL FURNACES AND RELATED APPARATUS

SURPLUS FURNACES FOR SALE

BOX TYPE				**BOX TYPE RECIRCULATING**			
24x36x18	Lindberg	50KW	2000°F	36x36x36	Despatch	Gas	1250°F
36x72x23	G.E.	72KW	2000°F	72x12'x42	Lindberg	Gas	1250°F
48x84x24	American	100KW	1850°F	24x36x24	Lindberg	45KW	1400°F
24x36x14	Surface	Gas	1850°F	36x48x24	Lindberg	45KW	1250°F
54x96x24	Surface	Gas	1850°F	66x16'x76	Lindberg	180KW	1250°F
PIT TYPE				**PIT TYPE CARBURIZERS**			
25x36	Lindberg	66KW	1250°F	10x20	Hevi Duty	14KW	1800°F
28x28	Lindberg	52KW	1250°F	15x18	L&N Homo	30KW	1800°F
48x72	Lindberg	Gas	1250°F	20x36	L&N Homo	72KW	1800°F
48x96	Surface	Gas	1250°F	25x36	L&N Homo	85KW	1800°F
48x96	Lee Wilson	Rad. Tube		20x48	L&N Homo	85KW	1800°F
CONVEYOR TYPE RECIRCULATING				**ROLLER HEARTH**			
36x33'x12	Despatch	MshBlt	Gas 875°F	28"	G.E. 17'htg. 70'C.	320KW	2050°F
27x15'x12	R&S	MshBlt	Gas 1250°F	28"	G.E. 28'htg. 90'C.	497KW	2050°F
48x20'x12	Surface	PitBlt	Gas 1000°F	62"	G.E. 18'htg. 45'C.	655KW	1650°F

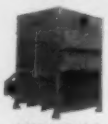
SEND FOR COMPLETE LIST

THE JOE MARTIN CO., INC.
19256 John R. St. **TWinbrook 2-5500** **Detroit 3, Mich.**

LIST NO. 160 ON INFO-COUPON PAGE 170

KOZMA *Eventemp* RECIRCULATING FURNACES

PIT TYPE



OVEN TYPE

PROVIDE CLOSE TEMPERATURE CONTROL FOR:

- Drawing, tempering and stress relieving
- Heat treating of brass and copper
- Solution heat treating and aging of aluminum
- Heating aluminum for forging

EVENTEMP recirculating furnaces offer highest heating efficiency plus the convenience of push-button operation. Available in either gas fired or electric models in a wide range of sizes and capacities, KOZMA *EVENTEMP* FURNACES assure accurate temperature control within a range of 300° to 1650° F.

For complete information write:

J. A. KOZMA COMPANY, 2471 Wyoming
Dearborn, Michigan

Electrosalt Furnaces . . . Radiant Forging Furnaces . . . Eventemp Pit and Oven Furnaces . . . Gas or Oil Salt Bath Furnaces . . . Melting and Smelting Furnaces . . . Gas or Oil Roller Hearth, Chain, Pusher and Rotary Hearth Furnaces.

J. A. KOZMA Company

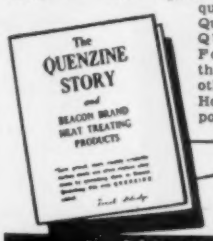
INDUSTRIAL PROCESSING FURNACES SINCE 1928

LIST NO. 158 ON INFO-COUPON PAGE 170

FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



KELCO

ALDRIDGE INDUSTRIAL OILS, Inc.

3401 W. 140th St., Cleveland 11, Ohio

LIST NO. 29 ON INFO-COUPON PAGE 170

END POT FAILURE

Switch to *scheduled* pot maintenance with low-cost pressed-steel pots for lead, salt, cyanide, oil-tempering, metal-melting. Can't turn suddenly defective, because no faulty steel survives drawing. Request catalog from Eclipse Fuel Engineering Co., 1018 Buchanan St., Rockford, Ill.

Eclipse INDUSTRIAL COMBUSTION DIVISION

LIST NO. 176 ON INFO-COUPON PAGE 170

HAWKRIDGE METALS CORPORATION

Producers and Sellers of

TITANIUM POWDER

−40 to +300 mesh

High Purity	99.2% Pi
Commercial	98.6% Pi

North Hampten
New Hampshire

LIST NO. 177 ON INFO-COUPON PAGE 170

ARco AIR WASH SYSTEMS

PLATING • PICKLING • METAL CLEANING *FUME SCRUBBING*

- Reasonable initial cost . . . economical in operation . . . no moving parts . . . efficient in performance . . . compact—requires little space . . . standard units—7200 to 57600 C.F.M. Write Dept. "MP" for complete information.

AUTOMOTIVE RUBBER CO. • INC.
12550 BEECH ROAD • DETROIT 39, MICH.

LIST NO. 154 ON INFO-COUPON PAGE 170

STANWOOD HEAT TREATING EQUIPMENT RETORTS and STACKING BASKETS

• REPRESENTATIVES IN PRINCIPAL CITIES
of new Cor-Wal construction give you:
• Lighter weight—yet stronger
• Longer service life
• Sides are heat resistant corrugated rolled metal
• Basket grid, grid supporting ring and top ring are of high temperature cast alloy
• Proved in exhaustive tests on the job
WRITE FOR DETAILS
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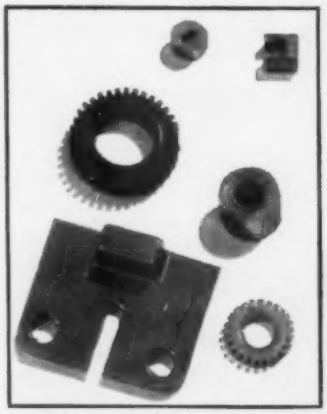

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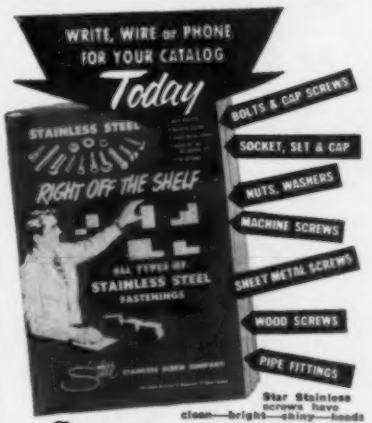

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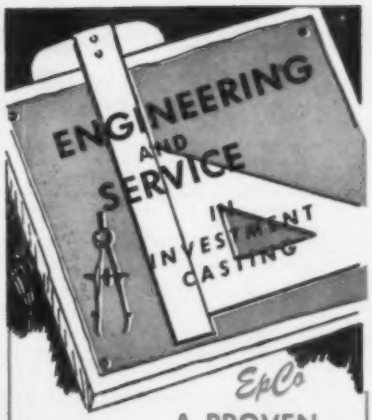

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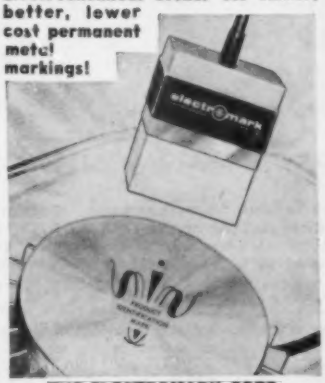

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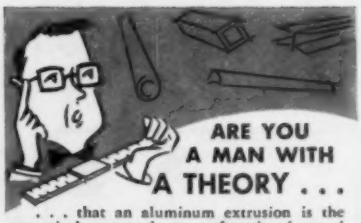

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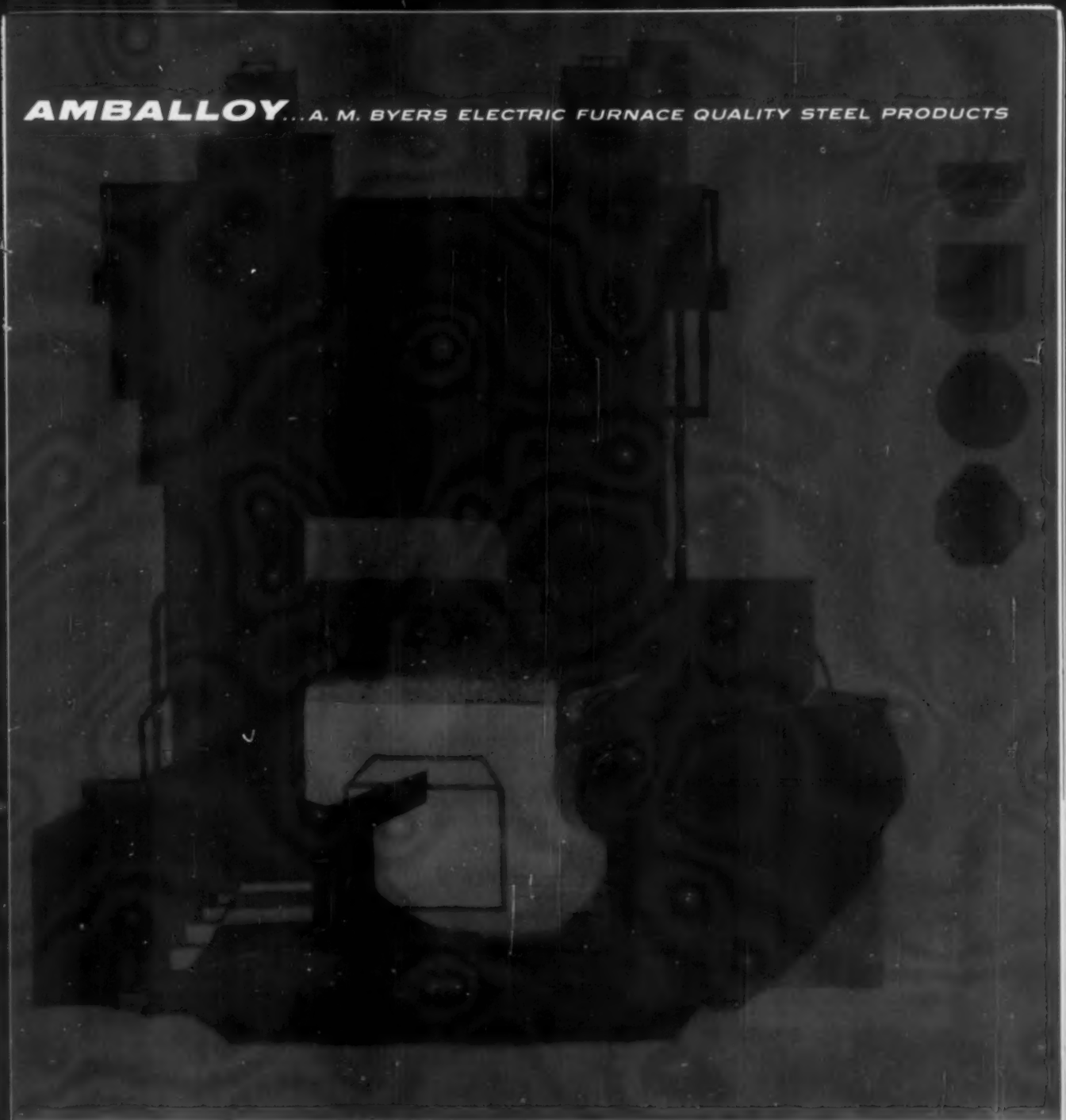

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Metal Pyrotechnics

Digest of "A Survey of Available Literature on the Rapid Combustion of Metals in Air", by Saul Haffner, U. S. Department of Commerce, Office of Technical Services, Reprint No. PB 121347, 18 p.

THE RADIATION characteristics of metals and alloys during rapid combustion in air at high temperature are of great importance in the development of photoflash bombs and signal flares.

The various characteristics studied by different authors include dust flammability, explosion pressure, minimum explosive concentration, ignition energy, heat and temperature developed, total light output, efficiency of illumination, spectral distribution, flash time, emissivity and actinity.

Numerous methods have been used to study the above properties. For example, the color temperature of metal flames has been determined by the use of nitra lamps of known temperature and spectral distribution with a contrast photometer. The spectral energy distribution was observed by means of a glass and a quartz monochrometer in conjunction with a photo-electric cell and a highly sensitive ballistic galvanometer. Another research worker studied the same property using a calibrated standard lamp and a logarithmic step-sector rotating at 5000 rpm. The spectrum has also been determined as a function of time by means of a spectrograph equipped with a focal plane shutter.

When aluminum powder is burned in air, the spectrograms show a continuum, plus bands from aluminum oxide and certain aluminum lines. It is concluded that the emitter is in a vaporous state, and that the continuum is emitted by the condensation of droplets of aluminum oxide. Time-intensity curves are obtained by using an oscilloscope with a ballistic galvanometer.

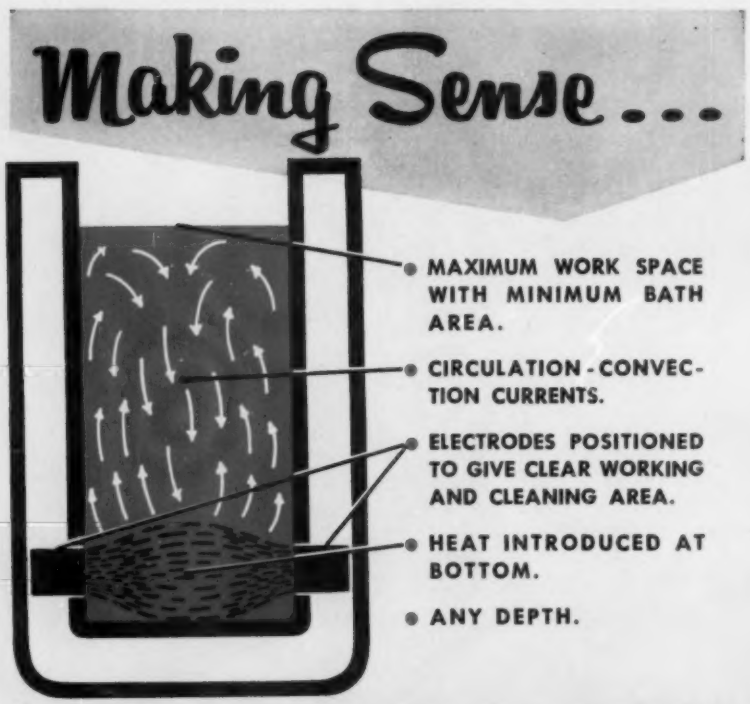
The author proposes the use of newly developed instruments such as the electronic integrator, the rapid scanning spectrometer, and other photo-electric devices for a basic study of the combustion of metals.

Except for the very rare metals, most metals have been studied in many forms including wire, ribbon, foil and powder.

In one particular investigation, the explosive hazard of more than a hundred types of metal dusts, encountered in industrial manufacturing processes, were studied. Dusts of Zr, Mg, Al, Ti and alloys of 50-50 Mg-Al can be ignited by weak electrical sparks. Others such as Fe, Mn, Si, Zn, Te, Sb and Cd are moderate dust explosion hazards while still others, Cu, W, Co, Ni, and Mo, were very difficult to ignite. The inflammation of aluminum powder is a chain reaction in which radiation participates to a great extent.

Additions of Mg, Cd, Zn, and Li were made to aluminum to study their effect on amount of emitted light, efficiency of illumination, and duration of flash. Cadmium and zinc, for example, will increase the ease of combustion of aluminum in oxygen. The addition of only 1% magnesium to aluminum increases its flammability by a considerable

(*Cont. on p.* 174)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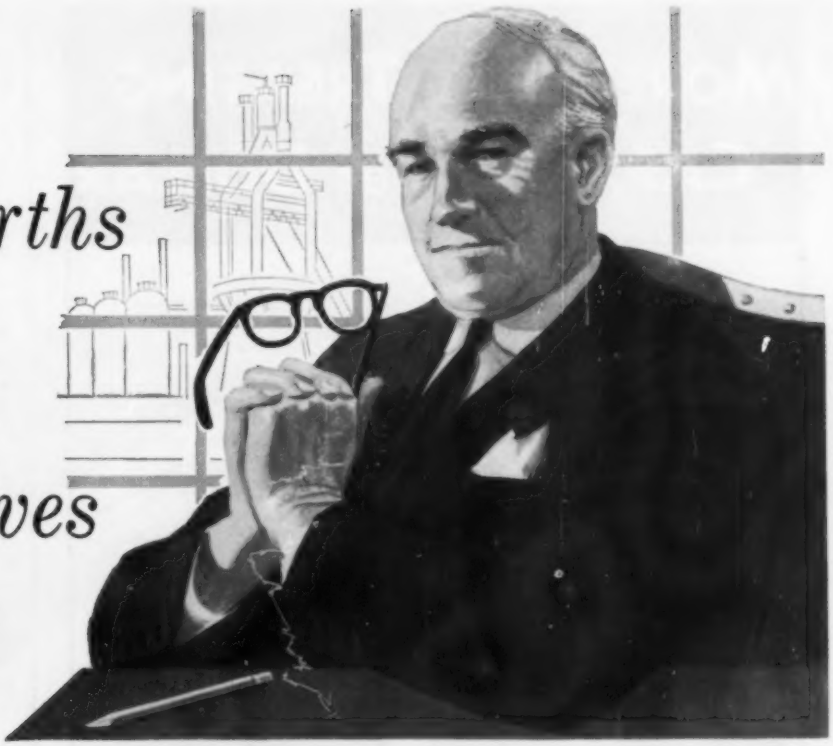
Rare Earths and Steel Executives

?



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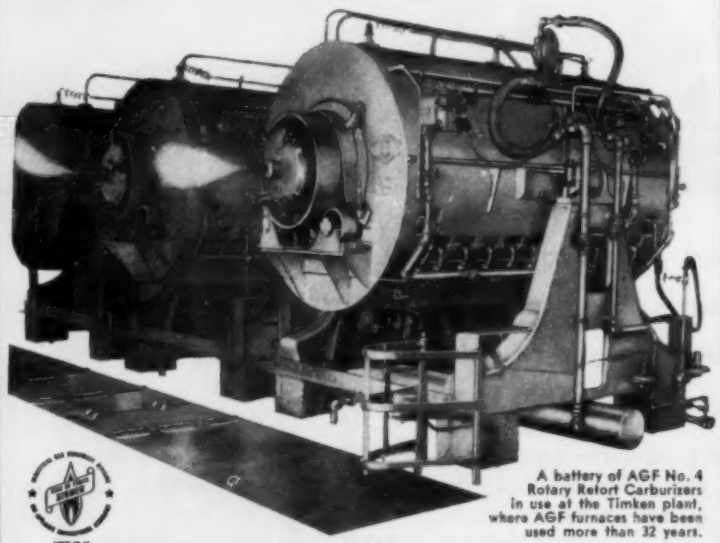

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Pyrotechnics . . .

amount and greatly decreases the flash time. The total light emitted by zirconium wires and ribbons is proportional to the mass of zirconium and is equivalent to 36 lumens per watt. Thorium and titanium produce 26 and 25.5 lumens per watt respectively. The lumen-second is however advocated as the unit for light measurement. A table is given of the light output of various metals and combinations of metals where it is observed that the output in lumen-seconds for 1 mg. of the metal is 441, 700 and 750 respectively for pure zirconium, magnesium, and aluminum metals. An alloy of 91% Al, 7% Mg and 2% Zr gives an output of 1100 lumen-sec. and is the most efficient alloy, for a given weight, from the standpoint of light output. Other tables give flash time, flammability, and illuminating power of metals, alloys and mixtures of metal powders and metal salts.

Although this bibliography was the first step of a project for the development of better military pyrotechnic items, many of the papers covered two subjects of industrial importance—photoflash bulbs and dust explosion hazards in industry. Consequently, the review should be of great interest to these industries.

H. P. TARDIF

Rolling Defects in Steel Sheet

Digest of "The Detection of Rolling Defects in Steel Sheet", by A. M. Armour, *Metallurgia*, Vol. 54, December 1956, p. 301-304.

VARIOUS DIFFICULTIES in drawing, pressing and welding operations are caused by subsurface defects in steel sheets. Internal splits or layers of inclusions occurring on planes parallel to the surface are troublesome defects characteristic of flat rolled products. Internal discontinuities of this kind are commonly known as laminations. Unfortunately, steel producers have been unable to eliminate completely these laminations which generally originate from ingot segregations or from internal tearing during rolling. Con-

(*Cont. on p.* 176)

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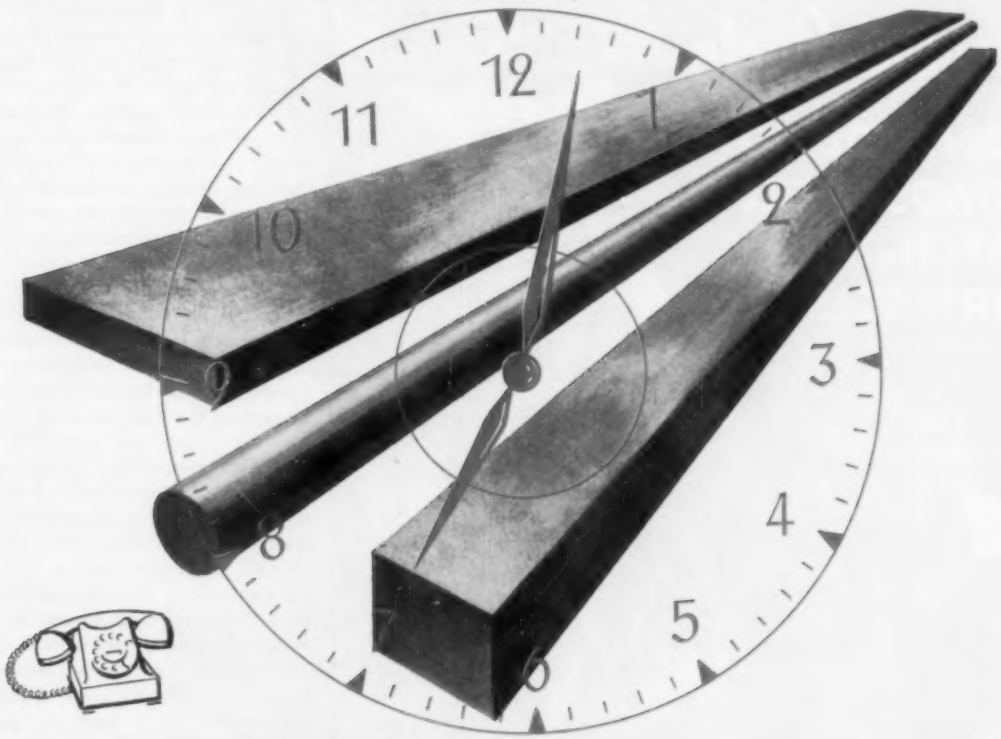

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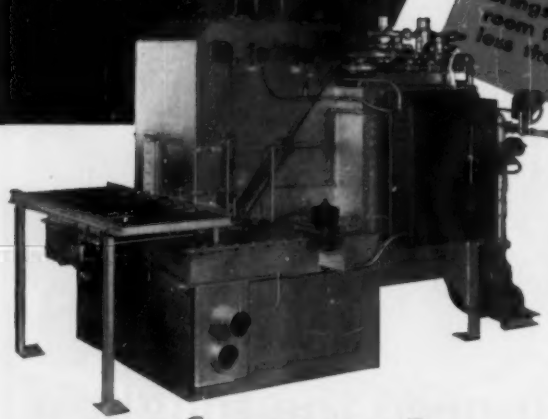

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Rolling Defects . . .

sequently, various nondestructive testing methods have been developed and used for detecting laminations in sheet steel.

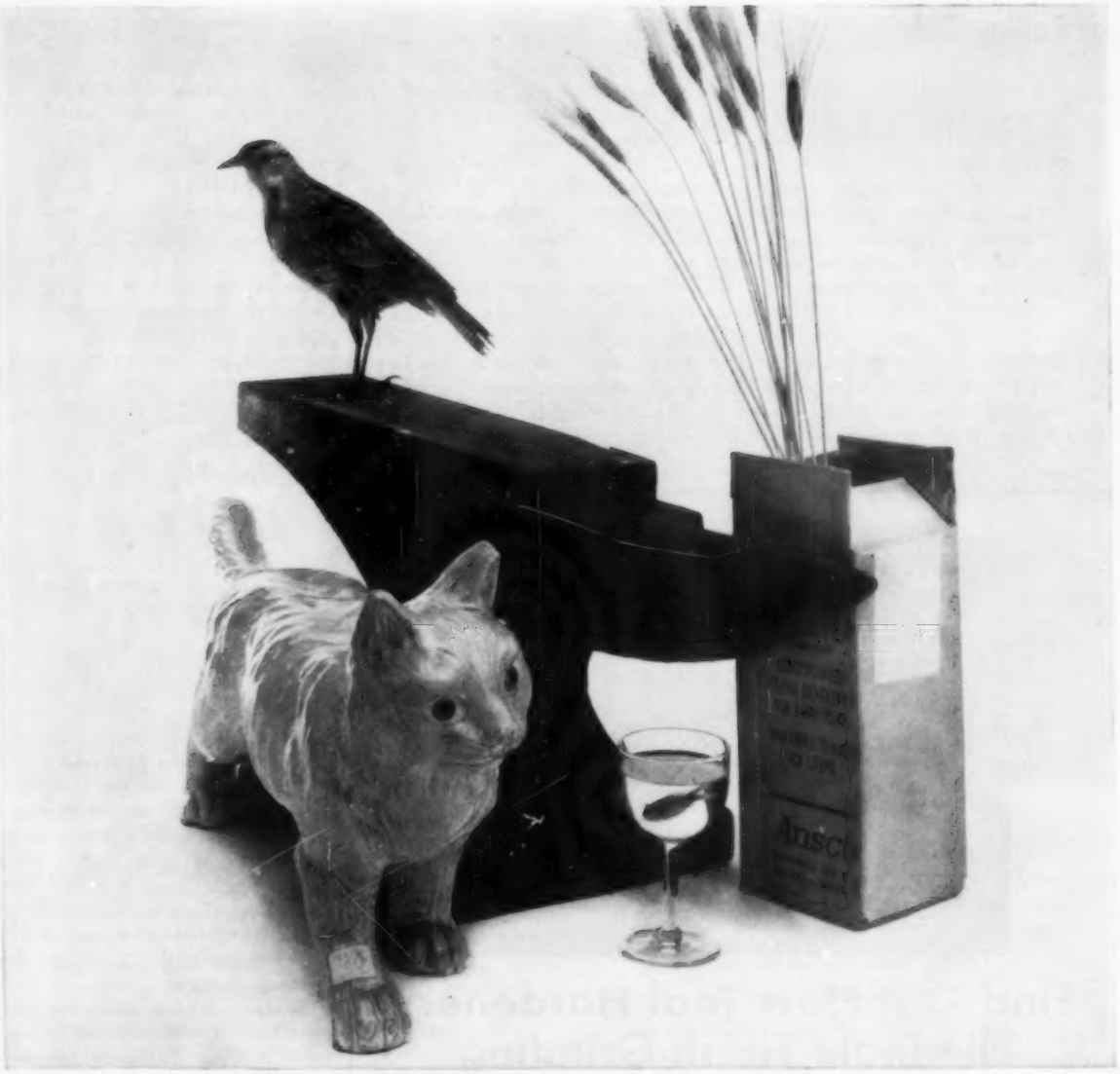
Normal rolling practices elongate the laminations in the direction of rolling but not in the transverse direction. This simplifies the inspection problem because scanning the sheet on lines normal to the rolling direction gives a reasonably good estimate of the internal quality of adjacent, uninspected regions. Mechanical, electrical, ultrasonic and magnetic methods can be used for detecting internal planar defects.

Mechanical inspection methods are useful because laminations are usually covered by small bulges or blisters on the sheet surface. Therefore the subsurface defects can be detected by polishing a streak across the sheet with emery cloth. Because they are abraded more severely, the raised tops of the internal defects develop a brighter surface. Sheets are ordinarily a few thousandths of an inch thicker than normal in the regions containing laminations. This permits their detection by measurements of sheet thickness using a micrometer or a go-no-go gage. Although thickness measurements have not been widely used for locating internal defects, they would seem to justify further development because of their inherent simplicity, economy and adaptability to faster inspection rates.

Electrical resistance measurements can be used to detect subsurface discontinuities in clean, bright sheets with fair rapidity. The method is less suitable for sealed or hot rolled steel sheets covered with nonconducting oxide films.

The equipment includes a source of continuous current and a ballast resistance in series with two contacts which can be placed opposite one another on the two sides of the sheet. Two additional contacts, connected to a millivoltmeter, are placed on the sheet close to the other contacts. By this expedient the I²R drop through the sheet can be measured without including the contact resistance. As the four contacts, fixed in location with respect to each other, are moved across the sheet the millivoltmeter records potential

(*Cont. on p.* 178)



Hunter, hunted and hunting

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Industrial X-ray

Rolling Defects . . .

differences. When the electrical contacts span a lamination, the current flows parallel to the surface instead of across the sheet thickness. This increases the resistance and indicates the location of the internal defect.

Ultrasonic inspection methods require that a track across the sheet be oiled in order to insure good contact between the metal and the crystal probe. Either the double probe transmision or the single probe reflection principles of supplying and detecting ultrasonic vibrations can be used for inspecting sheets. The internal defects reduce the amount of ultrasonic energy transmitted through the sheet and change the reflection patterns. The indications obtained with either type of equipment are readily interpreted.

Magnetic methods for locating internal defects in sheet steel depend upon the principle that the reduction in metal volume in zones containing inclusions influences the bulk magnetic properties; the smaller cross section of steel in unsound regions causes a localized increase in flux density and local magnetizing force when magnetic saturation is effected. The operating field of about 50 oersteds can be produced by a permanent magnet moved across the sheet. The local differences in magnetic field strengths in the space above the sheet surface can be measured by a magnetometer attached to the magnet. A transparent plastic dish containing a suspension of iron oxide powder in a suspension of paraffin oil can also be used as a field detector. Development work has been carried out in an effort to increase the speed of magnetic inspection procedures by increasing the area magnetized and by using magnetic and electromagnetic scanning devices.

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TRADEMARK

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Zone Purification of Metals

Digest of "Zone Purification", by Harvey S. Goering, *Battelle Technical Review*, Vol. 5, November 1956, p. 7-9.

THE ZONE MELTING PROCESS, developed primarily as a method of purifying germanium for use in transistors, is an adaptation of the fractional crystallization technique. The process depends on the difference in solubility of the impurities in the liquid and the solid material being purified. A relatively narrow cross section of the ingot is heated to a molten state; this band moves along the axis of the solid and newly solidified material follows at the freezing interface.

Equipment used must take into consideration contamination by container materials and gases, but generally the charge is placed under an atmosphere contained within a glass or quartz tube surrounded by an induction coil which can be moved along the length of the ingot.

Occasionally diffusion of the impurities to or away from the interfaces may not be fast enough to allow equilibrium conditions to be established at the freezing interface. In such instances agitation of the liquid zone and slow travel rates help to overcome this difficulty.

Where the solubilities of the impurities in the liquid and the solid differ appreciably, best results are obtained. Impurities which lower the melting point concentrate in the liquid zone and are moved along the axis to the end of the ingot. Impurities which raise the melting point

(*Cont. on p.* 180)

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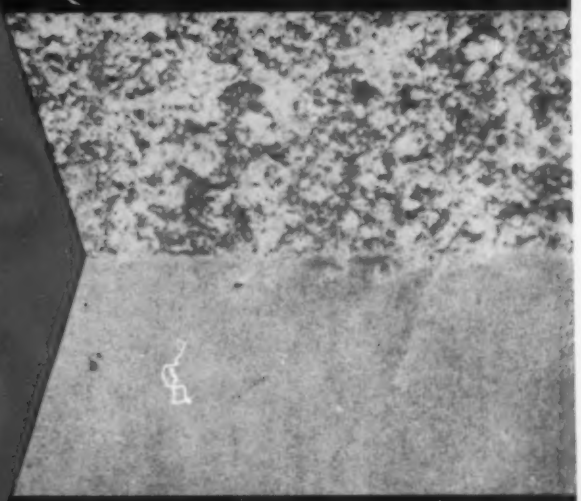

HERE'S UN-RETOUCHED PROOF! Lower portion of aluminum coupon was coated with Turcoat 4178. Upper portion was not coated. Entire coupon was then subjected to 800 hour salt spray test. Note that uncoated portion has been virtually destroyed while Turcoated portion shows only superficial blemishes.

only* PAINT-GRIPPING, CORROSION-RESISTING TURCOAT 4178 *offers you all these plus values!

QUICK FIXING—Turcoat 4178 coatings become non-smearing immediately upon withdrawal from processing. Parts can be handled freely *while still wet* without danger of smearing or streaking coating.

MEETS MIL-C-3541—Used by aluminum fabricators the nation over for government and non-government jobs involving aviation, building parts, household appliances, luggage, ornamental aluminum, aluminum foil, irrigation pipe, automotive and truck parts and bodies, etc.

EASY TO USE—Applied by spray, dip or hand methods. Requires no heating . . . no electric current. Easily controlled by mere pH adjustment.

UNIFORM—No light tell-tale untreated sections around welds, corners or holes.

ECONOMICAL—Used at low concentrations. Extremely long-lived. Will accept tremendous contamination without loss in efficiency.

COLORS—Available in gold iridescent or natural aluminum.

FREE **SHOWING—TRAINING MOVIE!**
"ALUMINUM FINISHING"

New full-color film visually demonstrates every aspect of aluminum finishing from laboratory theory to authentic production-line techniques filmed on-the-spot during mass production. If your plant or technical group is interested, write today for full details without cost or obligation.

WRITE FOR TECHNICAL DATA . . . FREE! 4 pages full of technical information on Turcoat 4178, the quick-fixing aluminum conversion coating. Write for your *free* copy, without obligation . . . *today!*

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6135 SO. CENTRAL AVE., LOS ANGELES 1, CALIF.
Factories: Newark, Chicago, Houston, Los Angeles, London, Rotterdam, Sydney, Mexico City, Naha (Okinawa)
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- ☐ Please send free technical information on Turcoat 4178
- ☐ Please send details on the training film "Aluminum Finishing."
- ☐ Please have salesman call

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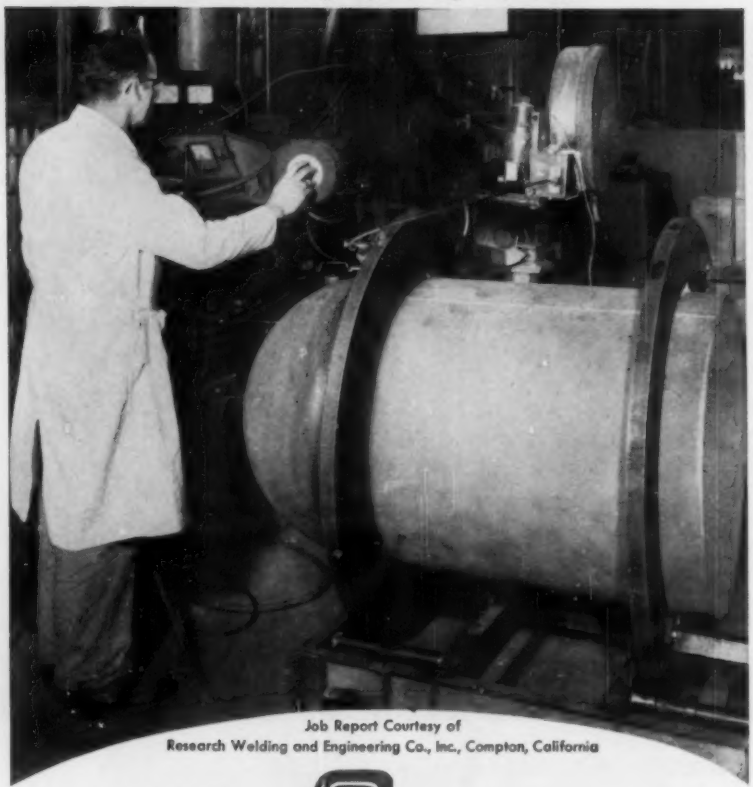
Weld from one side only . . .
Get X-ray quality welds

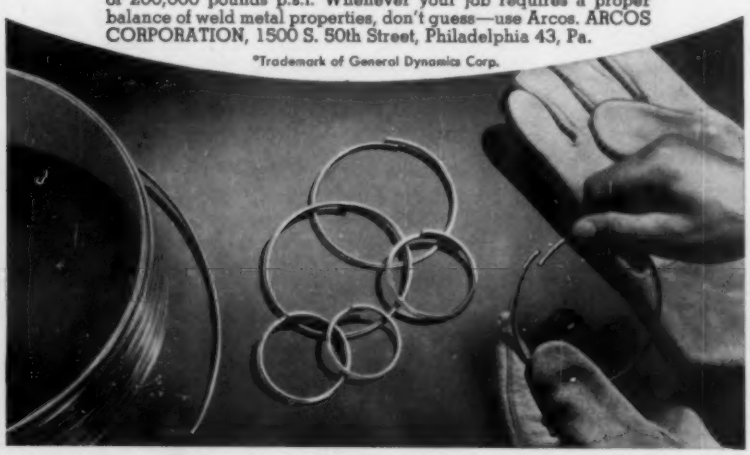


Job Report Courtesy of
Research Welding and Engineering Co., Inc., Compton, California

USE THE ARCOS EB* WELD INSERT

This welded missile tank had to weigh less than 600 pounds and yet contain air under pressure of 3,000 p.s.i. Arcos EB* Consumable Weld Inserts were used in automatic inert gas arc welding of the dished heads to the tank body. The inserts saved weight by eliminating back-up rings. They also allowed welding to be done conveniently from one side only and produced 100% x-ray quality root passes. Chromenar CMV coiled wire for submerged arc welding was used to complete the welds. After heat treatment the welds matched the base metal, with tensile strength in excess of 200,000 pounds p.s.i. Whenever your job requires a proper balance of weld metal properties, don't guess—use Arcos. ARCOS CORPORATION, 1500 S. 50th Street, Philadelphia 43, Pa.

*Trademark of General Dynamics Corp.



Zone Melting . . .

concentrate at the opposite end. With large differences in solubilities, extreme purification is possible with a few passes. However, when the impurities do not show a marked preference for the liquid or solid state, only a slight purification is obtained with each pass and many passes are required to obtain acceptable results. Purities of 99.999999% are commonplace for the zone melting process as compared with a purity of but 99.99% normally produced by other purification methods.

Zone purification is generally accepted as a necessary technique for the production of high-purity semiconductors such as garmanium, silicon and tellurium. It has also been used effectively on antimony, indium, copper and tin.

The process is equally useful in the purification of compounds. Gallium cannot be successfully purified by zone melting, but gallium chloride reacts very well, and this purified compound can be electrolized to yield pure gallium.

Drinking water can be obtained from sea water by a controlled freezing or "zone melting" technique. Another intriguing possibility is the potential use of the process for the large-scale separation of organic compounds.

Although currently limited to small quantities of material and to use as a research tool, large-scale production applications in the future are quite possible. Commercial quantities of high-purity germanium form a present-day result.

H. B. Osborn, Jr.

Liquid Metals

Digest of "Some Aspects of Liquid Metals", by L.H.J. Harper, *Journal* of the Birmingham Metallurgical Society, Vol. 36, March 1956, p. 346-355.

Until quite recently interest in liquid metals has been limited to foundry technology and the pouring of castings. During the past decade, however, increasing emphasis on the development of nuclear power has led to important new applications for liquid metals as coolants and fuel dispersion mediums for nuclear reactors. This has been

the starting point for a great deal of fundamental work on the properties of liquid metals.

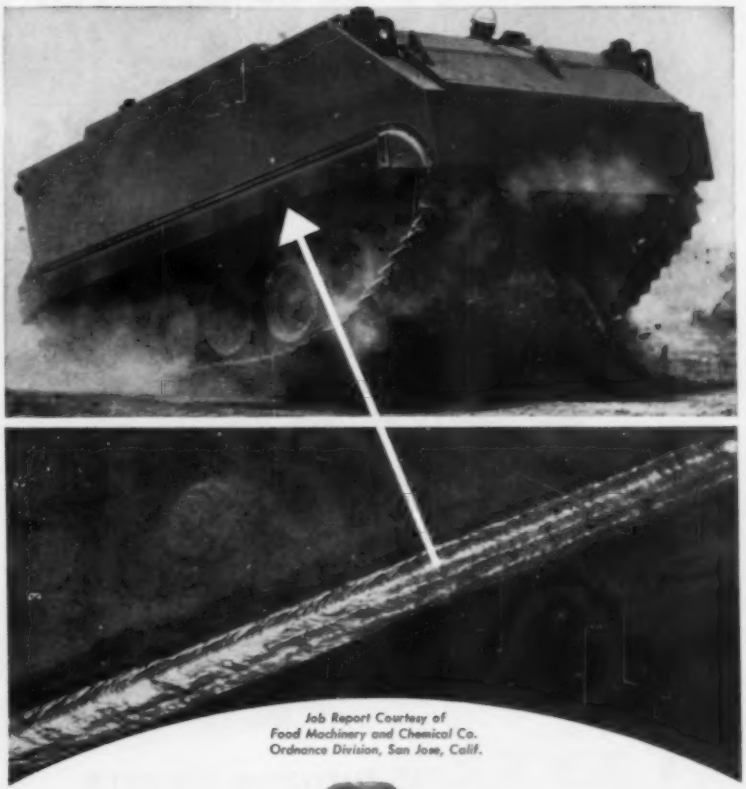
This paper, according to the author, does not describe a particular piece of research, it is not a review in a strict sense, nor does it mainly deal with what has been accomplished and what is known; instead it stresses those aspects about which there is controversy or doubt and where much work must be done in the future. Some of the fundamental aspects of the structure of liquid metals are presented. Attention is given to properties such as viscosity and surface tension, and their relation to some practical problems. Finally recent applications are discussed along with some future possibilities.

The structure of a liquid can reasonably be expected to be intermediate between the orderly array of the solid state and molecular chaos of the gases. The changes in physical properties on melting suggest that the liquid is more like the solid than the gaseous state. The latent heat of fusion is much less than the latent heat of vaporization. The change of volume on melting is quite small. Changes in electrical and thermal conductivity do not suggest any complete and catastrophic breakdown of the solid structure. Such observations suggest the existence of short-range order in liquid metal. The changes in electrical and thermal properties can be explained on the assumption of such order. The number of free electrons is almost the same in solid and in liquid. Thus, although there is a tendency to close packing in the liquid, the atoms are not on a lattice as in the solid state; instead certain groups of atoms show a statistical preference for certain relative positions. These positions form an array but there are no permanent crystals or crystallites.

A liquid is distinguished from a solid in every-day experience by its ability to flow into and fill a container. In flowing, forces are set up that tend to resist flow. The magnitude of these forces is expressed as the coefficient of viscosity. Under conditions of streamlined flow this coefficient is defined as the shear stress divided by the rate of shearing strain. Turbulent flow is more common in practice, however, and this

(*Continued on p.* 182)

How to produce low alloy welds to resist tons of torture

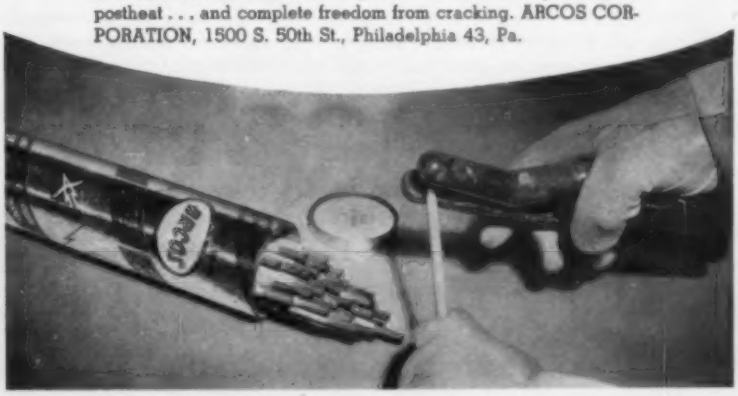


Job Report Courtesy of Food Machinery and Chemical Co. Ordnance Division, San Jose, Calif.

WELD WITH ARCOS

LOW ALLOY ELECTRODES

This 22½ ton armored personnel carrier proves an important point. When working with hard-to-weld low-alloy plate, and welds must be extra strong and tough in the "as welded" condition, it pays to use the highest quality weld metal available. In this case, Arcos Tensilend 100, a low hydrogen coated electrode produced weld metal that matched the physical and chemical properties of the base metal. In addition, it did the job with less nickel than the 19-9 modified electrode formerly used. There was no preheat, no postheat . . . and complete freedom from cracking. ARCOS CORPORATION, 1500 S. 50th St., Philadelphia 43, Pa.



ROLOCK
FABRICATED HEAT AND CORROSION RESISTANT ALLOYS

BIG maintenance savings

BIG furnace covers

These heavy 309-S Stainless covers are literally "big as a house"... about 20′ x 8′ x 4′. Previous designs were the best available, but the customer told us it took a skilled welder at least one shift a week to keep the seven covers in service. Use of Rolock's unique "corrugated" construction, with provision for proper expansion and contraction in service, essentially eliminates all of this maintenance.

This is just one more example of the improved performance and substantial savings credited to Rolock's engineering approach to tough fabrication problems, when coordinated with our extensive modern plant facilities and specialized skills in high heat-resistant alloy fabrication.

Today, Rolock is producing a wide range of important equipment in the fields of furnace hoods, covers and bells, pit-type furnace retorts and equipment, vacuum retorts, pressure and vacuum vessels, in addition to standard equipment fabricated in the high heat-resistant alloys.

Let us submit recommendations and quote on your next tough job. General Catalog G-10A will be sent on request.

SALES AND SERVICE REPRESENTATIVES FROM COAST TO COAST

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JOB-ENGINEERED for better work
Easier Operation, Lower Cost

Liquid Metals . . .

complicates the treatment. The conditions for turbulent flow can be estimated from a knowledge of the viscosity coefficient η by the equation $N = \frac{SVD}{\eta}$ where N is the Reynolds' number, V is the average velocity, D is the diameter of the tube, and S is the density of liquid. If N is less than 2000 the flow is streamlined; if more than 2000 the flow is turbulent.

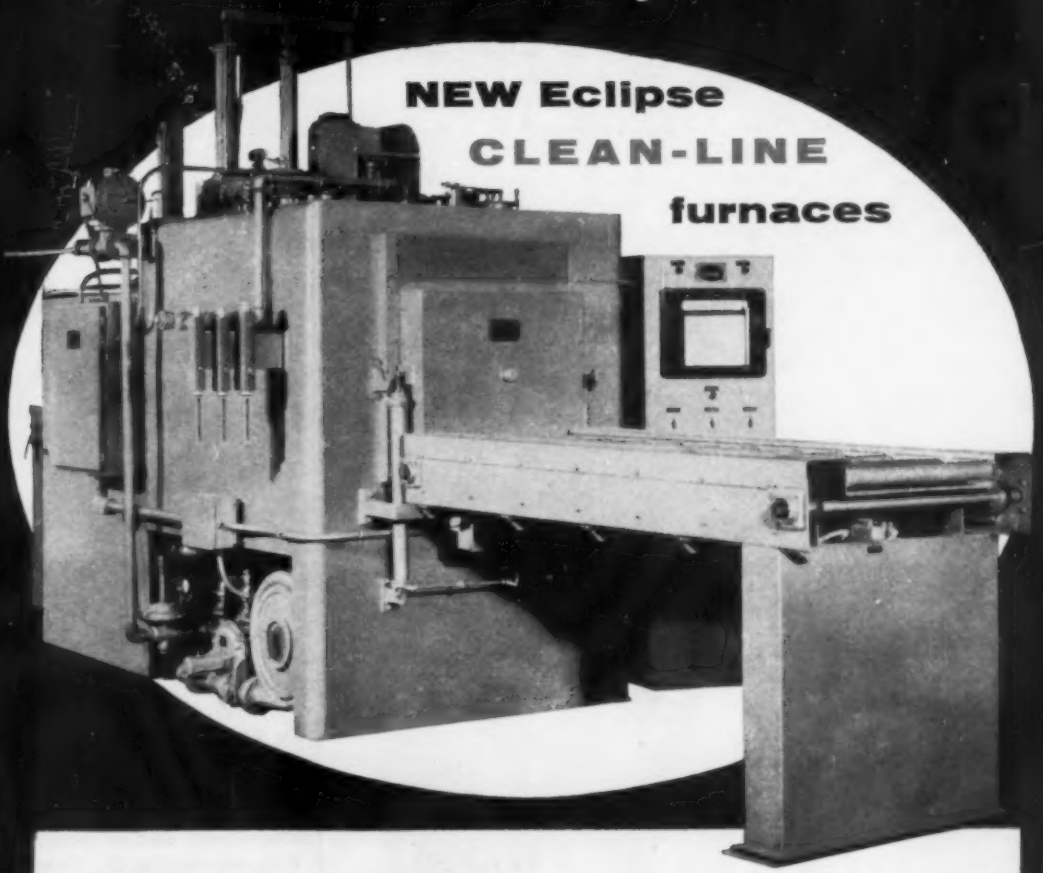
The metallurgist is mainly interested in the variation of viscosity with the variables commonly under his control, namely temperature and composition. Thus there are two cases of viscosity-composition relationship worthy of consideration: First, in alloy systems there is the variation of viscosity with constitution; second, there is the variation of the composition within a single-phase field. Usually the second case is concerned with the effect of impurities. For example, an examination of the viscosity-constitution curves for the tin-zinc system reveals the existence of maximums at the composition corresponding to maximum solid solubility and minimums at points where solidification takes place isothermally, that is, for the pure components and eutectics. Hence, viscosity is roughly proportional to the inverse of the solidification range, and the effect of solid soluble impurities is to increase the viscosity.

From these and numerous observations dealing with other fundamental properties of liquid metals such as surface tension and fluidity, the surprising yet seemingly irrefutable fact emerges that some properties of an apparently homogeneous liquid are very closely related to the constitution of the solid alloy.

Although some of the problems discussed in this paper are no longer critical, many others remain to be solved. Further work in this field will be spurred by the knowledge that future sources of power, and the well-being of large areas of the earth, will depend upon a thorough knowledge of the science and technology of liquid metals. Likewise, the continued development of long-established industries will also depend upon such knowledge.

W. W. Austin

Brings more uniformity to heat-treating



MORE uniform quench

MORE uniform heat

MORE uniform case depth

All these "plusses" are yours with the new Eclipse Clean-Line furnace because: (1) atmosphere and temperature are distributed with complete uniformity during heating — there's no stratification — and (2) even tightly packed loads of the smallest parts are quenched uniformly in the oil jet-agitated tank served by the high-capacity pump. The Clean-Line furnace, rated to heat-treat 400 lb of work in one hour, and with quench capacity for 700 lb per load, is designed for fully automatic clean hardening, carbonitriding, carburizing, carbon restoring, or annealing. Standard Clean-Line furnaces are designed for operation at temperatures up to 1850° F.

Complete control of all heat-treat operations is right at your fingertips. You can select an air or oil quench, for example, just by flicking a switch on the control panel. Heating cycle, high oil pump circulation, and quenching cycle for a particular workpiece can all be controlled precisely and automatically by three separate timers on the control panel. All these features add up to better quality — every piece in every batch.

WRITE for bulletin and data sheets describing the Clean-Line system that includes endothermic generators, automatic washers, and tempering units.

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ECLIPSE FUEL ENGINEERING CO., 1727 Buchanan Street, Rockford, Illinois

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Pyrophoricity of Metallic Titanium

Digest of "Hazards and Safety Precautions in the Fabrication and Use of Titanium", Report No. 63, Titanium Metallurgical Laboratory, Battelle Memorial Institute, January 25, 1957, 20 p.

TITANIUM is not classed as a metal which needs to be harnessed; it is a metal which, like many other metals, can be potentially hazardous if certain precautions are not taken in its use. In the processing, fabrication and use of titanium and its compounds, certain fire, explosion and health hazards exist.

Fine particles of titanium originating in machining, grinding, sawing or drilling are a definite fire hazard, not only because of the fire properties of the metal but also because of sparks developing in these operations. Small particles from sawing, for instance, ignite easily and burn with a red glow. Fine turnings from finish machining cuts can be ignited by a match. Both continue to burn quietly with a hot glow after the flame or initial source of heat has been removed. If heavy tool cuts are taken it is recommended that water or water-base coolants should be used because of the danger of igniting oil-type cutting lubricants.

In dry grinding, particles seem to oxidize and become inert, but this work should be done with constant breaks to allow heat in the material (of low heat conductivity) to dissipate. Grinding machines should be equipped with water exhaust systems. In wet grinding, only water or water-base coolants should be used and sludge should not be permitted to dry out before it is removed to an isolated outdoor location.

Coarser turnings and chips, as well as sheet, plate, bar stock and forgings, are extremely difficult to ignite.

Explosive reactions have occurred during stress-corrosion studies of titanium and various of its alloys in red-fuming nitric acid, one such incident resulting in a fatality. Although the mechanism is not fully understood, it could be related to decomposition, presence of relatively large amounts of iron and carbon as impurities in the metal, friction between samples during testing, corrosion of the metal by intergranular attack or discoloration.

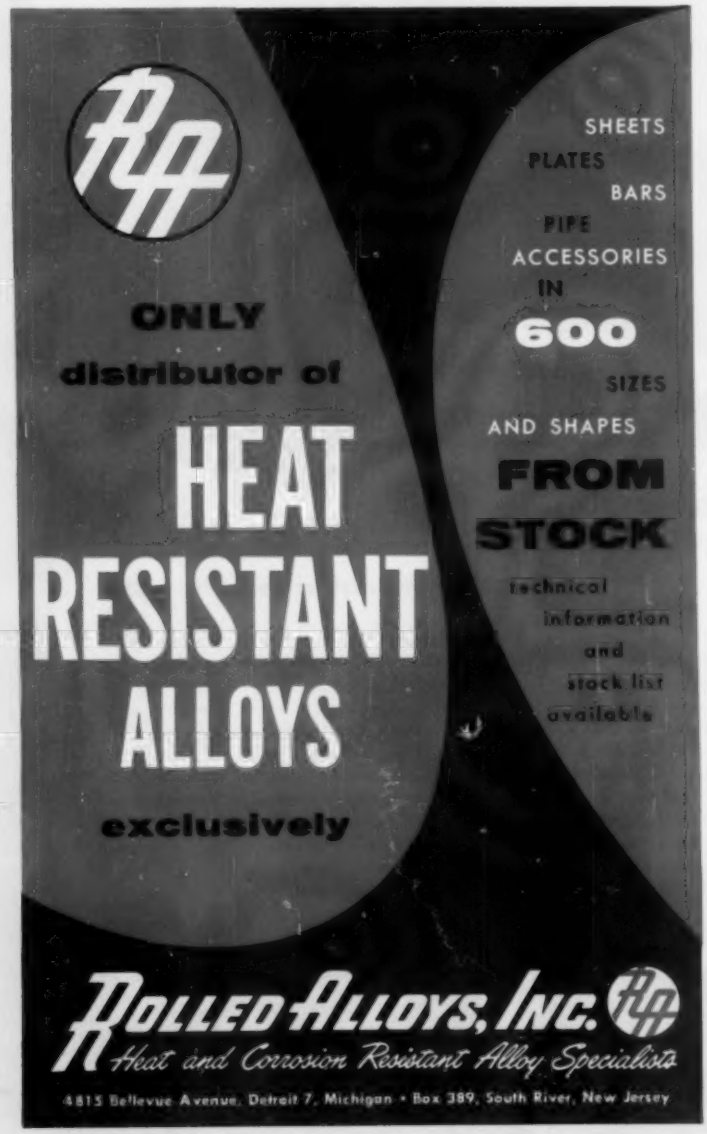
For the most part, titanium is not thought of as a toxic material. Rather, toxicity is associated with compounds of the metal, alloying ingredients, or with chemicals involved in the processing of titanium itself.

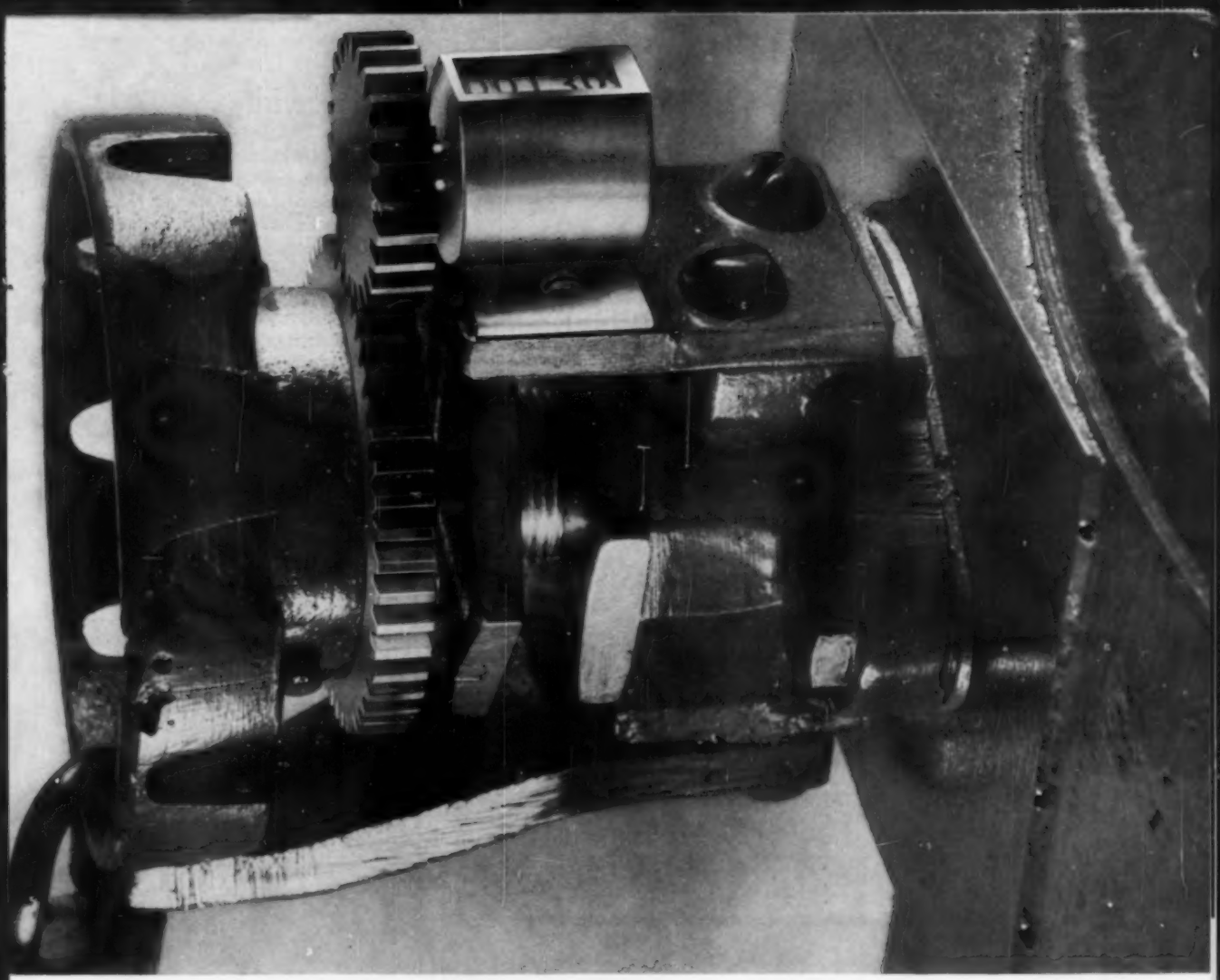
In the chemical cleaning or treating of titanium, precautions must be taken to avoid operator inhalation of toxic fumes and to prevent burns from corrosive acids. Conventional degreasing methods should include an effective ventilating system to remove toxic vapors.

In the production of titanium sponge, toxic fumes are a hazard, and these are, for the most part, associated with the chemicals used in the process. First, if the batch in the reduction pot has not cooled sufficiently prior to opening and exposing the contents to air, the lower chlorides of titanium may flash and the entire batch may ignite. Second, upon opening the distillation unit, finely divided magnesium and titanium powder may burn. This can be prevented by bleeding in some dry air prior to opening the unit.

Handling of titanium powder is one of the most hazardous phases of working with the metal. It should be stored in a cool, ventilated area, away from any potential fire areas, open flames or powerful oxidizing

(*Cont. on page* 186)

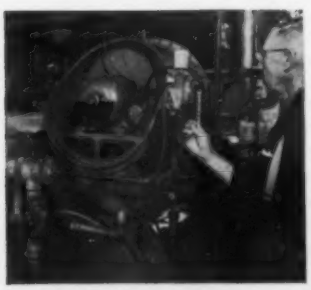




Air-gas Ratio Valve

For precise control of furnace atmospheres . . .

Come to Kemp



Twin installation of Model 6-MR Atmos Gas Generators deliver up to 6,000 cfh at Thomas Strip division of Pittsburgh Steel. Increased equipment capacity, reduced labor costs, and closer control make Kemp units money savers in every installation.

For heat treating and annealing metals in inert atmospheres, you can rely on Kemp Atmos or Nitrogen Generators as a dependable source of inert gasses. Kemp generators are built around the patented Kemp Industrial Carburetor, which guarantees a steady supply of exact analysis inerts, regardless of demands on the line. With Kemp units supplying your furnaces, you get greater control . . . a better product at lower cost.

The Kemp Atmos Generator, a rich exothermic gas producer, is suitable for most furnace applications; while for more critical uses the Kemp Nitrogen Producer is recommended. Both are noted for durability and dependability. Rugged Kemp design gives optimum performance for years, with only minimum maintenance and care.

Kemp generators may be engineered as an integral part of new furnace construction, adapted to existing units, or furnished as a separate setup.

Your Kemp Representative, listed in the Chemical Engineering Catalog, will give you complete details. Or write direct for Bulletins I-100 and I-101. The C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore 2, Md.

Kemp Convection Dryers

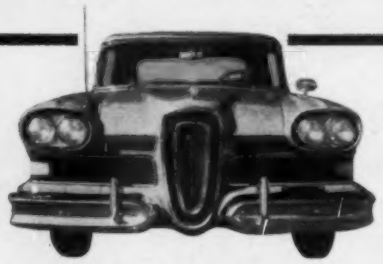
Kemp Immersion Melting Pots

KEMP OF BALTIMORE

Kemp Industrial Carburetors

Kemp Orlad Dryers

How about Malleable?



The 1958 Edsel

America's Newest Automobile includes Malleable Iron Castings as important components

Power steering housing

Transmission rear brake drum

Universal joint flange

Recognized for its durability and versatility for over 130 years, and used for parts in all kinds of transportation equipment, it's not surprising to find applications of standard and pearlitic Malleable castings throughout the Edsel.

The three Edsel parts examples illustrated are important uses of malleable. The power steering mechanism housing is certainly a place for safety insurance. The universal joint flange is a vital link in the power train. And the transmission rear brake drum helps complete the flow of engine power to the car's drive wheels.

It's very likely *your* product could be strengthened, lightened or improved by the use of malleable iron castings. And malleable's easy machinability speeds production and cuts costs. A helpful review of *all* malleable iron advantages is contained in our new publication "Value Analysis". Write for your copy — to the Malleable Founders' Society.

Consult a malleable foundry engineer at the drawing board stage.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

Pyrophoricity . . .

agents. Good ventilation is essential to prevent explosive concentrations of titanium dust in the air. Such dust clouds have been known to explode at temperatures as low as 625° F. It is also advisable to provide adequate pressure relief in buildings and equipment to reduce damage from explosive pressure.

Extinguishing titanium fires is not easy. Use of carbon dioxide or chlorinated hydrocarbon extinguishers is not recommended since these chemicals tend to intensify the combustion. In general dry powders such as powdered limestone are considered helpful in controlling fires by extinguishing them at the surface but not throughout the burning mass.

No confirmed adverse physiological reaction has been attributed to titanium. This fact, together with the metal's corrosion resistance, relative lightness and low modulus of elasticity, have led to its use in orthodontic appliances and orthopedic surgery. Titanium dioxide has been used as a pigment for years and exhaustive tests have proved its negative effect on the human body. Titanium chloride, on the other hand, is a severe skin irritant and after hydrolysis forms toxic hydrochloric acid fumes.

ARTHUR H. ALLEN

Automatic Feeding of Magnesium for Die Casting

Digest of "Automatic Metering of Magnesium for Cold Chamber Die Casting", by F. L. Burkett and F. C. Bennett, presented at American Foundrymen's Society Convention, May 1957, 12 p.

THE MECHANIZATION of the casting process has made it possible for the pressure die casting industry to grow rapidly. A typical conversion economy is that all zinc die castings are now made in high-speed, semi-automatic die casting machines of the hot chamber type, featuring automatic supply of the molten alloy.

However, most die-casting alloys such as aluminum, magnesium and brass, which melt at higher temperatures, are still manually transferred

(*Continued on p.* 188)

Let's LAUGH a minute

Of course everyone knows that heat treating today has become one of the most serious technical and vital functions of the current metalworking activity. But a smile and laughter are still also important and the cartoons shown here are for that purpose.

We hope they make you grin and when it's heat treating services you require or skilled, technical advice about part design or heat treatability, check with

METAL TREATING INSTITUTE
271 NORTH AVENUE
NEW ROCHELLE, NEW YORK

or any member listed below.

Sound Familiar?
SMEARCASE, THE PRODUCTION MAN, SCHEDULES A JOB THROUGH HIS PLANT WITH TIME TO WASTE!
LET'S SEE... PLENTY OF TIME FOR A GOOD JOB ON OPERATION 1 ...NUMBER 2 SHOULD BE ABLE TO OOZE ALONG NICELY... AMPLE TIME FOR OPERATION NUMBER 3 ...THEN OUT IT GOES FOR HEAT TREATMENT
PRODUCTION SCHEDULE
OPER. #1
OPER. #2
OPER. #3
BUT... WHEN THE HEAT TREATER GETS IT...IT'S IN AN AWFULLY GREAT HASTE!
SMEARCASE! HOW'S THAT JOB COMING? TIME'S RUNNING OUT!
FINE, BOSS! I GOT IT TO THE HEAT TREATER 10 MINUTES AGO, I'M CHECKING WITH THEM NOW!
HELLO! ABC HEAT TREATING? WHAT? NOT THROUGH WITH OUR JOB? DO YOU REALIZE WE HAVE A TIGHT SCHEDULE? TRYING TO MAKE ME LOOK BAD, HUH? BLAH, BLAH, BLAH...

Sound Familiar?
CARELESS MILFORD IS NOT PARTICULAR ABOUT THE PARTS HE SENDS IN FOR HEAT TREATING...
BOY!... TAKE A LOOK AT THIS CASTING!
...OFF SIZE, WICKED, CRACKED AND WHAT HAVE YOU. HOW DID IT EVER GET OUT OF THEIR PLANT... OR DON'T THEY CARE?
Just-Rite Heat Treating Co.
BUT... WHEN HE GETS THEM BACK... WHAM! LOOK WHO GETS THE BLAME!!!
CALL YOURSELVES METAL TREATERS? HAH! YOU SURE GAVE OUR CASTINGS THE 'TREATMENT'! - THEY GO OUT OF HERE 100% PERFECT,... AND WHAT HAPPENS? DO YOU DROP 'EM OFF THE ROOF OR JUST RUN A TANK OVER THEM? IF YOU HAVE NO CONSIDERATION FOR A CUSTOMER'S PRODUCT I'LL JUST HAVE TO...

American Metal Treatment Co.
Elizabeth, New Jersey

Anderson Steel Treating Co.
Detroit, Michigan

Benedict-Miller, Inc.
Lyndhurst, New Jersey

Bennett Heat Treating Co., Inc.
Newark 3, New Jersey

Commercial Metal Treating, Inc.
Bridgeport, Conn.

Cook Heat Treating Co. of Texas
Houston 11, Texas

The Dayton Forging & Heat Treating Co.
Dayton 3, Ohio

Deminy Heat Treating Co.
Dallas, Texas

Drever Company
Philadelphia 23, Pennsylvania

Greenman Steel Treating Company
Worcester 5, Massachusetts

Fred Heinzelman & Sons
New York 12, New York

MTI MEMBER
METAL TREATING INSTITUTE

Alfred Heller Heat Treating Co.
New York 38, New York

Hollywood Heat Treating Co.
Los Angeles 38, California

Ipsenlab of Rockford, Inc.
Rockford, Illinois

L-R Heat Treating Company
Newark, New Jersey

The Lakeside Steel Improvement Co.
Cleveland 14, Ohio

Metallurgical, Inc.
Minneapolis 14, Minnesota

Metallurgical, Inc.
Kansas City 8, Missouri

New England Metallurgical Corp.
South Boston 27, Massachusetts

Owego Heat Treat, Inc.
Apalachin, New York

Paulo Products Company
St. Louis 10, Missouri

Pittsburgh Commercial Heat Treating Co.
Pittsburgh 1, Pennsylvania

Pittsburgh Metal Processing Co., Inc.
Pittsburgh 15, Pennsylvania

The Queen City Steel Treating Co.
Cincinnati 25, Ohio

J. W. Rex Company
Lansdale, Pennsylvania

Stanley P. Rockwell Company
Hartford 12, Connecticut

Scott & Sons, Inc.
Rock Island, Illinois

Syracuse Heat Treating Corp.
Syracuse, New York

Temperature Processing Co.
North Arlington, New Jersey

CANADA

Ipsenlab of Canada Ltd.
Toronto, Ontario

WORLDS
LARGEST
STOCK
52100
STEEL
Peterson
STEELS, INC.
Union, New Jersey • Detroit, Michigan • Melrose Park, Illinois

Die Casting . . .

to the machine by a hand-ladling operation. This is hazardous, costly, and inefficient. Hand ladling also has the often overlooked disadvantage of being conducive to poor quality of the finished casting, because metal temperature and transfer time are subject to uncontrollable fluctuations. With an increase in casting size, operator fatigue becomes more acute. Automatic feeding reduces the routine movements, resulting in a marked increase in possible production rates.

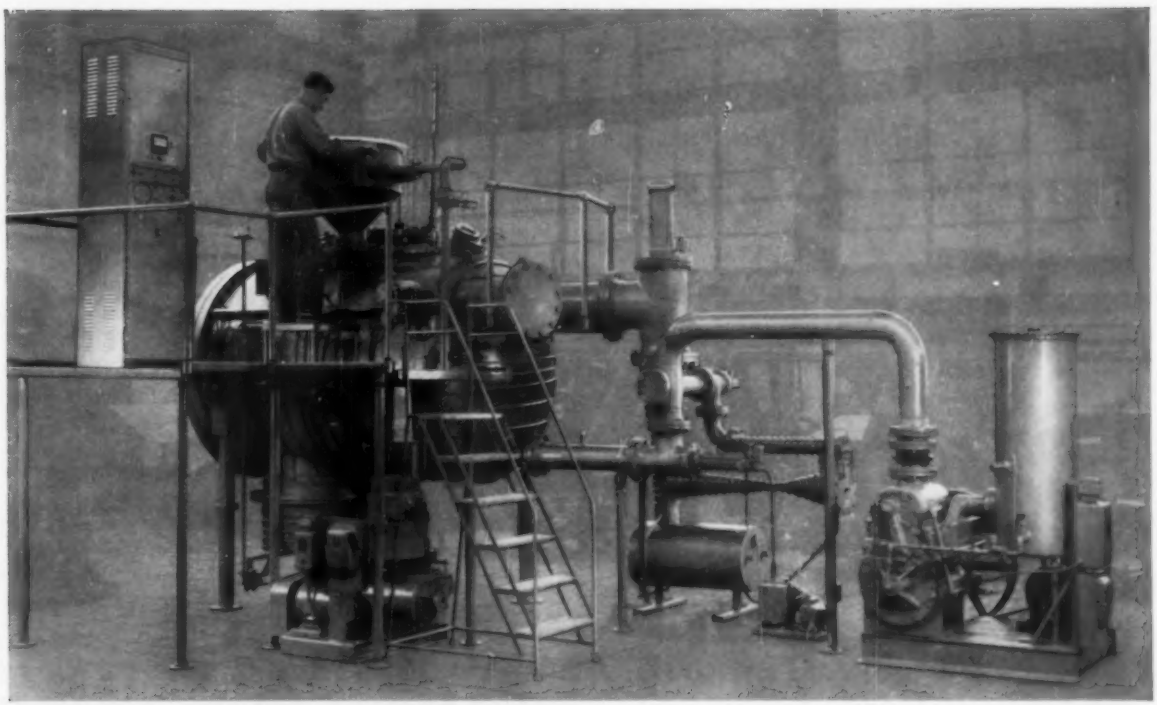
Development work at the Dow Chemical Co. indicates that mechanical valves employing metallic components offer the most promising possibilities for containing and controlling magnesium alloys.

The Dow automatic metering device works in the following manner: The magnesium alloy is charged to the gas or electrically heated steel holding pot, the molten metal being protected from oxidation by a conventional flux or sulphur dioxide atmosphere. The metal from within the pot flows by gravity through a heated transfer pipe to a valve immediately above the shot well of the die casting machine. Both valve and transfer pipe are maintained at a predetermined temperature, and discharge of the molten metal for each "shot" is electrically controlled by a sequence wired into the die-casting machine circuit. Thus, as soon as the operator presses the die-close button, the machine closes the die, the automatic feed is energized to release a constant weight of metal into the shot well, the machine shot plunger injects the metal into the die cavity and, finally, after a preset holding time, the machine opens, and the finished part is ejected.

Automatic metering has increased production rates without overheating the die. At the same time, by assuming uniform metal transfer conditions, the surface appearance and internal equality of individual castings appear to be improved.

Since the machine operator no longer needs to move to the injection end of the machine to hand-ladle metal into the shot well for each cast, his movements are reduced appreciably. The die is lubricated automatically. It should be remembered

(*Cont. on p.* 190)



New modular-type vacuum induction furnace—Model FIM-300—50 to 300 pounds capacity.

Here's your special vacuum furnace

. . . it comes from our standard stock . . . and it stays special

Like a lot of new fields, vacuum metallurgy is growing and changing fast, making it hard to plan processing that will match the market as years roll by.

Solution: *Modular* Furnaces

One sure answer to this predicament is to buy *modular* furnaces . . . units you can expand as the need arises. Such a furnace is our new 50 to 300-pound furnace.

It handles melts as small as 50 pounds efficiently. With the correct size crucible you can take the basic unit up to 300 pounds. Observation windows, a bridgebreaker, a charging cup with interlock, and a gauge-valve relay rack cabinet give you the controls you need for uncomplicated vacuum metallurgy.

If or when your needs call for even more critically controlled production, the basic unit is ready with built-in accommodations for such things as a sampling device, immersion thermocouple, and optical sight tube.

Semi-continuous operation, too

There's a 12-inch flange above the crucible for adding a bulk-charging chamber. The 36-inch diameter mold well will take a 34-inch mold table. When you want to go to semi-continuous production, these two changes will greatly expand your output. For example, you could pour six 300-pound ingots—1800 pounds—without breaking vacuum.

The mold well, by the way, is flanged and can be provided in a variety of depths. Even with the standard well you can pour in molds 48″ deep.

And so, if you want to break into vacuum metallurgy in a modest way with provisions for future expansion that will not sacrifice your initial investment, this is your furnace. Get to know it better by writing for our Bulletin P4-36.

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formerly Consolidated Vacuum

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Duties: Challenging, stimulating work. R & D on nuclear fuel materials, including radiation effects, selection and evaluation of uranium and thorium alloys, and ceramics. Also related work in mechanical fabrication development.

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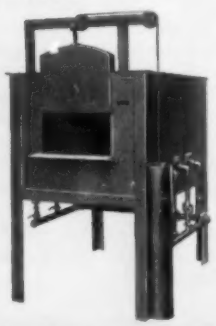
Outstanding service since 1911! Each unit, with the famous "BUZZER" Venturi, delivers the hottest, quickest heat attainable without a blower. Full range control of heat and turn-down. Standards or specials available for manufactured, natural or liquefied gas applications.



HIGH SPEED FULL MUFFLE FURNACES, Bench Type for heat treating high speed and alloy steels — temperatures to 2400° F.

LARGE FLOOR TYPE OVEN FURNACES for universal heat treating of larger pieces — temperatures to 2000° F

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CHARLES A. HONES, INC.

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Die Casting . . .

that magnesium alloys require but a minimum of lubricant, which can be added at the machine shot well.

Shot weight is set by a simple turn of a control knob on the automatic metering timer and can be established accurately within the limits of ½ to 10 lb. Since the flow rate from a valve may vary with the pressure of the hydraulic head, a Dow-developed "metal level sensor" and compensating device correct the automatic metering instrument so that the delivery of uniform shot weights is assured. Experience has shown that reproducibility of metered metal amounts does not vary more than 5% of the holding pot metal head. This in turn is conducive to rapid casting rates since minimum solidification periods can be maintained if each biscuit is controlled to close size and weight tolerances. The safety hazard of "exploded biscuits" on opening the die is also greatly minimized.

Installation of automatic metering equipment on conventional die-casting machines of the cold chamber type is simple, since it requires no fundamental change. All utilities and controls are provided with quick disconnects, permitting flexible scheduling and operation. Various metals can be accommodated by the same machine.

Start-up time is about 3 hr., and maintenance is reduced to a minimum. Since the valve stem is the only moving part operating in the molten metal, the automatic feeding mechanism can be readily serviced.

HANS HEINE

X-ray Inspection by TV

Digest of "Television Equipment for Testing Welded Pipes", *The Engineer*, Vol. 203, May 17, 1957, p. 772.

FROM 1934 until 1956 much of the mechanically welded steel pipe produced at the Thyssen Works of the Phoenix Rheinrohr Co. in Mulheim, Germany was X-ray inspected by spot tests. As many as 8000 film exposures were made per month. To permit continuous X-ray inspection of entire welds, direct viewing of the X-ray pictures on a fluorescent

(*Cont. on p.* 192)

Salt bath heat treating helps put you in a better competitive situation!

The Ajax files are full of case history records such as these. Each represents a typical instance where replacement of other heat treating systems with Ajax Salt Baths have meant important cost reductions or greatly improved quality—*and usually both:*

$37,000 WAS SAVED in 8-months by an Ohio manufacturer through using an Ajax Electric Salt Bath installation for 4 different cost-cutting operations i.e. carburizing, simultaneous carburizing and brazing; brazing; and hardening.

A 350% PRODUCTION INCREASE in 45% less space with 50% less labor was achieved in carburizing bearing races in a 6-unit Ajax Electric Salt Bath installation.

A 60% COST REDUCTION in case hardening body screws was scored by a single Ajax Salt Bath no larger than your desk but handling 390 lbs. of work per hour.

AN 80% REDUCTION in finish grinding time was obtained by martempering SAE-52100 bearing races in an Ajax installation. Drawn to Rc 62-63, the races showed average out-of-round distortion of only 0.002-0.003".

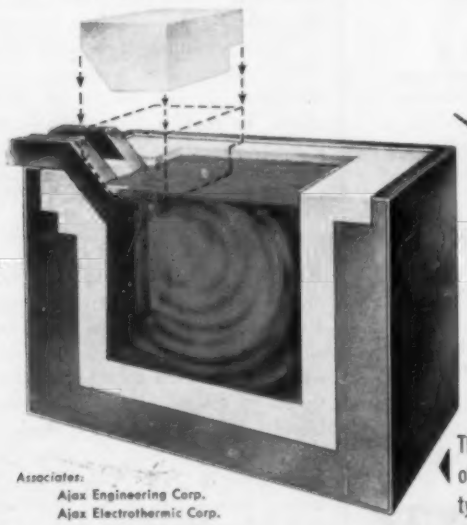
A 4 TO 5 TIME LIFE INCREASE for rock bits resulted from Ajax Salt Bath hardening which also made possible use of plain carbon rather than costly alloy steel. 480 lbs. of work per hour are handled in a bath only 36" x 11" x 36".

SIMULTANEOUS CARBURIZING AND BRAZING of a complicated motor starting assembly are done in one Ajax furnace with one heating of the work as compared to two heatings previously required.

Savings like these are vitally important—and Ajax can help you to realize them to the fullest extent.

The chief product of Ajax is applied heat treating "know how" . . . not merely the largest assortment of salt bath furnace types in the world. When you discuss heat treating matters with Ajax, you get full benefit of unmatched experience not alone in designing and selling furnaces, but in helping you utilize them to best possible advantage.

There is no obligation in having Ajax make a frank appraisal of your heat treating situation.



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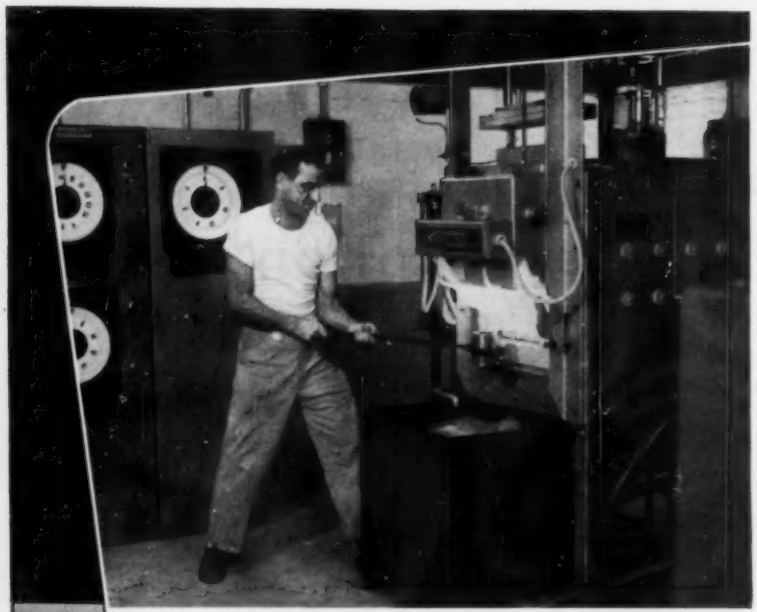
The most efficient heat treating principle for a wide variety of work . . . Pioneered by Ajax in the largest line of furnace types, shapes and sizes for modern production requirements.

PIONEERS IN SALT BATH HEAT TREATING PROGRESS



Faster solution-heat-treating with a Hevi-Duty

CONVECTION BOX FURNACE

The Beryllium Corporation uses this Hevi-Duty Multi-Range Convection Box Furnace in their process control laboratory for solution-heat-treating "Berylco", Beryllium Copper alloys. The laboratory director reports outstanding results and economy due to the following advantages:

1. Rapid heating to solution temperatures (1450 or 1700°F depending on the alloy being treated) is made possible by a motor driven fan that circulates the hot gases through the densest of loads, and by,
2. Direct, even heat radiation to all surfaces of the load by Hevi-Duty Return Bend heating elements on all six sides of the furnace chamber.
3. Control of temperature within ±5°, throughout the chamber.
4. Elimination of oxidation by use of a protective atmosphere.
5. Freedom of both hands for rapid charging, discharging and quenching by a foot treadle operated door.

For further information about Hevi-Duty Convection furnaces, write for Bulletin 341R.

HEVI-DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers *Constant Current Regulators*

X-ray . . .

screen was substituted about a year ago. Mechanically speaking it was a success. By means of an image intensifier the light was increased by a factor of 1000 so that steel sections as thick as 0.8 in. could be examined continuously. About 8.7 miles of weld was inspected in this way per month.

This method of inspection, however, was very tiring to the operator. To reduce eyestrain, and thus minimize mistakes, a television camera was installed to project, on several TV screens, the picture produced by the image converter and make it accessible to a number of inspectors. Either positive or negative screen images are obtained by this method.

GEORGE F. COMSTOCK

Heat Resisting Steels

Digest of "Chromium-Manganese-Nickel Heat Resisting Steels", by H. Krainer, *Archiv fur das Eisenhüttenwesen*, February 1957, p. 81; translated and condensed in *The Engineer*, Vol. 203, April 26, 1957, p. 647-648.

WHEN NICKEL was scarce in Germany during the war manganese was used in its place to produce austenitic high-chromium heat resisting steels. Manganese, however, is a weaker austenite-forming element than nickel and is not capable of producing a ferrite-free structure in steels containing over 15% chromium. Manganese promotes sigma formation in the ferrite of these steels, so that the chromium-manganese steels with 13% or more chromium become brittle after prolonged heating at 930 to 1470° F.

The increase in hardness produced by heating for 100 hr. at 1470° F. or 1000 hr. at 1200° F. in quenched higher-chromium steels containing 10% manganese and 2 to 4% nickel, and the smaller amount of hardening with nickel raised to 6%, are illustrated by graphs plotted from some German tests of 120 forged steels of this type. Increasing the chromium from 18% to 30%, with 2 to 4% nickel, raised the Brinell hardness from below 200 to over 500 in the tempered specimens, and decreased the impact values from 180 to less than 4 ft-lb. With 6% nickel in

steels containing 22 to 25% chromium and 10% manganese, the same tempering gave only about 220 to 300 Brinell hardness, and less embrittlement owing to less sigma formation.

The creep strength of the chromium-manganese steels at 1380° F. was superior to that of a chromium-nickel steel with 9% nickel, but the resistance of the former to scaling was inferior to that of the latter. The scaling resistance could not be improved by additions of silicon or aluminum without undesirable formation of sigma. Higher nitrogen suppressed sigma formation and improved the creep strength, especially with molybdenum or vanadium additions, but did not improve the scaling resistance.

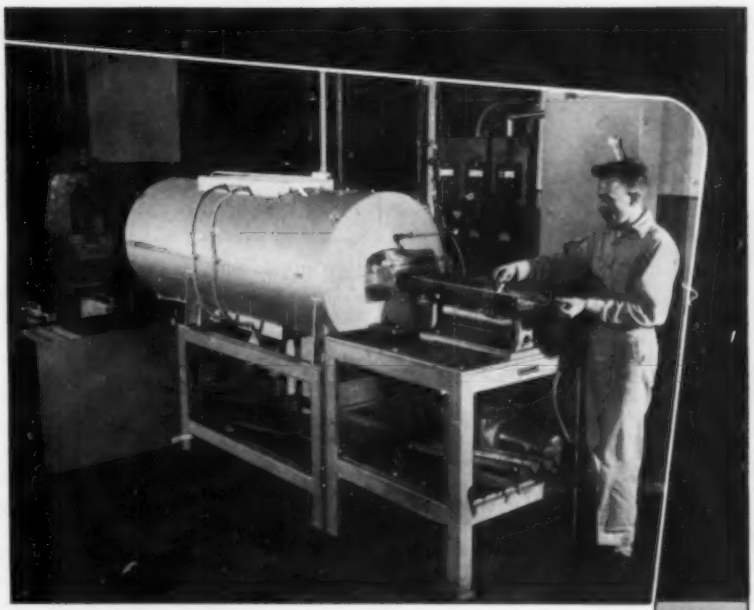
The composition recommended is 0.06% C,, 0.49% Si, 5.2% Mn, 18.0% Cr, and 6.3% Ni. This steel, after quenching from 2190° F. in water and tempering 1000 hr. at 1200° F. or 100 hr. at 1470° F., had a fully austenitic structure with less than 170 Brinell hardness and at least 159 ft-lb. impact value.

GEORGE F. COMSTOCK.

Metal Fatigue

Digest of "Fatigue and Its Relation to the Mechanical and Metallurgical Properties of Metals", by George R. Gohn, S.A.E. *Transactions*, Vol. 64, 1956, p. 31-40.

FATIGUE FAILURES are primarily caused by progressive strain-hardening stress concentrations arising from material imperfections, design or fabrication defects, or surface damage during use. Service conditions result in the deformation of a small volume of the metal at or near the surface. Here, the initial small fatigue cracks are formed; these cracks enlarge until failure occurs. The fracture surface shows two or more distinct zones: A smooth area showing concentric or oyster-scale markings, starting from a nucleus or stress raiser, and a rougher area which frequently shows bright crystalline facets. Usually only one crack is observed, but many cracks starting from corrosion pits may occur if the environment is corrosive. In the latter case the frequency of the applied stress also has an effect, lower testing speeds giving a lower number of cycles to failure. Cycle



Quality carbonitriding of small parts with a Hevi-Duty

SHAKER HEARTH FURNACE

Allen-Bradley uses this Hevi-Duty Furnace for carbonitriding stampings, springs, cams, and rollers. Norman Hetzel, heat-treat foreman, says, "This Hevi-Duty Shaker Hearth Furnace represents a modern technique in heat-treating that is consistent with Allen-Bradley's policy of using the best new equipment in the manufacture of quality products."

Improved quality of parts results from the combination of superior design features, a proper atmosphere in the furnace chamber and a direct oil quench.

Uniformity of Case Depth is obtained by simple regulation of time cycle and temperature.

Labor Costs are reduced by the ease of operation and elimination of pickling after heat treating.

To find out how you can put this modern production furnace to work for you, write for Bulletin 850A.

HEVI-DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers *Constant Current Regulators*

Now-

A FULL LINE OF

Luster-on® POWDERS

FOR CHROMATE TREATING

ZINC

#50: Bright, clear, lustrous, nickel-like, corrosion-resistant; requires leach.
#51: Similar to #50, but bluish chrome-like color.
#52: Low-cost, no leach, bright, passive.

CADMIUM

#50: See under Zinc, above.
#53: Improved solubility, control, safety in handling; requires leach.

COPPER & BRASS

Cobra: Bright, yellowish, decorative and/or protective film, non-fuming, single dip.

ALUMINUM

222M Sealer: Clear or colored film for corrosion protection and paint bond.

MAGNESIUM

MPD 60: Yellowish film for corrosion protection and paint base.

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Metal Fatigue . . .

frequency has a negligible effect in the absence of creep or corrosion.

The progressive strain hardening theory does not explain all fatigue phenomena. It has been observed that hard drawn copper wire subjected to reversed bending stresses developed "islands" of soft copper. A similar softening has also been shown to occur in Grade A bronze (5% tin), 80-20 cupronickel, 1100 and 3003 aluminum alloys, and low-carbon-titanium steel rods. This indicates that the formation of fatigue cracks is associated with a semi-plastic condition.

According to the dislocation theory, slip which precedes the formation of a fatigue crack is considered to take place by the propagation of dislocations. The piling up of these dislocations against an obstruction such as a precipitate particle can lead to the formation of a crack perpendicular to the slip plane.

A thorough understanding of the behavior of metals under alternating stress is of great importance to designers, since it has been estimated that 90% of all service failures result from fatigue.

One of the most important steps in reducing fatigue failures would be to eliminate stress-raisers or to increase the resistance to fatigue in the region of the stress concentration. For example the fatigue strength of phosphor-bronze sheet can be increased from 31,600 psi. to 47,000 psi. by shot peening. An explanation of the beneficial effect of shot peening may be that the deformation of a polycrystalline metal is inhomogeneous, due not only to the statistical orientation of the grains, but also to the influence of the free surface. Thus, when a metal is stressed, lattice distortions occur and further deformation is hindered. For an interior grain it has been shown mathematically that the total hindering effect is theoretically twice the relative hindering effect on a surface grain. From this it follows that if fatigue is caused by slip, then fatigue in a homogenous material is a surface phenomenon. Factors which increase the yield strength of the

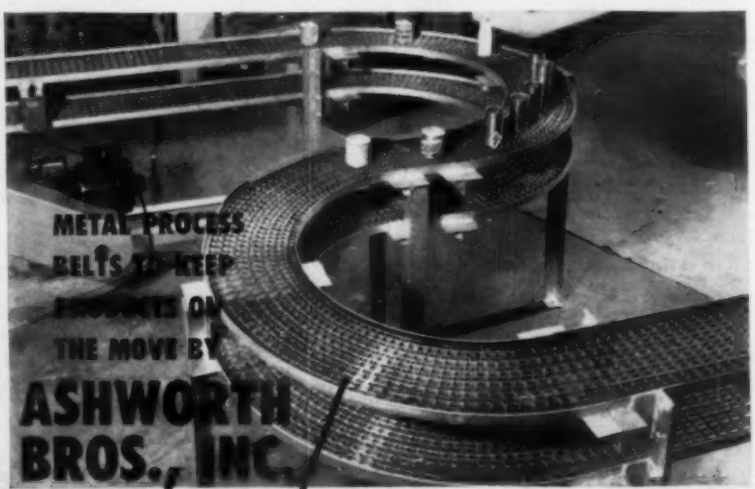
(*Cont. on p.* 196)

NEW

Economical . . . Flexible

NEW OMNI-FLEX® BELT by ASHWORTH

Let your production move around corners on the new, low cost Omniflex belt.
Short turning radius • light weight • easily installed • low maintenance factor



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Illustrated literature available, specify catalog M12.

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Special Reports On Finishing Non-Ferrous Metals

NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

Continuous CIRC-AIR Tempering

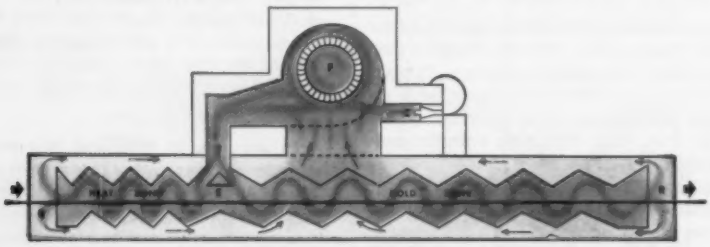
AT ± 5° F.

Industrial's "Circ-Air" tempering furnace is the most efficient heating machine ever designed.

The turbulent recirculation of hot gases through and around the work insures maximum and uniform heat transfer. Proper channeling of the hot gases to the work prevents wasteful dissipation of heat; and puts heat where it is needed — on the work.

A "Circ-Air" processing 2000 lbs. per hour at 1300° F., holding ±5° F., forces 14,500 C. F. M. of hot gases through the work. "Circ-Air" heating is recirculation at its best.

The continuous "Circ-Air" is suitable for heating steel, brass, aluminum and cast iron at temperatures up to 1450° F.



WHY THE CIRC-AIR IS THE BEST TEMPERING FURNACE!

The work is carried on a continuous conveyor. Loading can vary; ¼" bolts are densely loaded up to 3" deep. Less dense loading may be 20" deep. A 3' x 21' "Circ-Air" tempers over 2000 lbs. per hour.

Hot gases from the combustion chamber "C" and recirculated gases returning from the work chamber mix in the fan area "F." Entering the heating area through "T" at control temperature, balanced heat is directed to the charge and discharge ends, and is returned to the mixing chamber. The continuous V construction of the metal liner forces the hot gases up and down through the load at high velocity. The hot gases in the heating zone flow counter to the work. Heat transfer is rapid. Equilibrium is reached at point "E", and ±5° F. is held the length of the holding zone. Heating is without temperature head.

"Circ-Air" furnaces have been built in widths up to 108 inches, in lengths up to 165 feet, for temperatures from 250 to 1450° F., and capacities from 200 to 16,000 lbs. per hour. *Send for Bulletin 13-A*

INDUSTRIAL
HEATING EQUIPMENT CO.

CIRC-AIR 3570 FREMONT PLACE, DETROIT 7, MICHIGAN • WALNUT 3-7000

PIONEERS AND STILL LEADERS IN RECIRCULATION

Metal Fatigue . . .

surface layers of metals, such as electroplating, shot-peening, and case hardening increase the fatigue strength.

Because the tensile strength has been used widely in the inspection of metals, attempts have been made to correlate tensile strength with fatigue properties. For carbon steels the correlation is fair, and up to tensile strength values of approximately 180,000 psi. the endurance limit is about 50% of the tensile strength. This factor varies widely and it has been shown that although the tensile strength of copper-base alloys may be doubled by cold rolling (60.5 to 68.0% reduction) the fatigue properties were increased only 30 to 50%. It would thus be dangerous, from a design standpoint, to assume that the fatigue strength could be estimated from the tensile strength.

Ductility may prove beneficial in fatigue because local yielding at the base of notches permits a redistribution of stress which may prevent fatigue failure. Microscopic cracks may start in hardened materials with rough machined surfaces, re-entrant angles, keyways or threads, due to the high notch sensitivity of these materials. As yet, however, little work has been done to establish the relationship between yield strength and fatigue. Under conditions of completely reversed stress the fatigue limit is considerably less than the yield strength. For conditions of alternating or fluctuating stress superimposed on a mean stress other than zero the maximum stress amplitude in the cycle is limited by the yield strength.

Material with good fatigue properties usually has a small grain size. Surface finish also affects fatigue properties, and finishes formed by pickling or anodizing have an adverse effect. Size effects also play a part. In one experiment the fatigue limits decreased 15 to 20% for a series of steels as the size of the specimen increased from ⅛ to about 1 in. in diameter, but showed no further decrease with further increases in size to 2-in. diameter sections. In much larger sections lower fatigue strengths may be attributed to variations in the steel throughout the section. W. A. MORGAN

Any similarity to a real-life company is purely intentional

How did the lathe builder get the worm to turn?

Henry Wadsworth Headstock had a dream. About a better turret lathe. It used worm gears in the drives.

He not only doodled it — he dood it. And he got a venturesome soul to try out a pilot model of his new Turnabout Lathe.

Then his troubles started to multiply — like ants at a picnic. For the worm gears conked out with a sickening regularity. There were 12 replacements in 24 weeks. (Three guesses what the big wheels thought of *that!*) Things certainly were in one heck of a mesh.

Then Henry heard of Ampco Metal, the special copper-base alloy. And he had a worm gear made out of *it*. The last we heard, the Ampco Metal gear had been running for a whole year and still showed no signs of wear.

Frankly, we're not surprised. Gear service — in fact, *any* wear application — is duck soup for Ampco Metal. It resists deformation under heavy loads and speeds — so tooth contours hold their original shape. There's no scoring, no galling — the worm has true bearing action against the worm wheel. Damping characteristics, plus fine mating properties, reduce the noise of the gear set.

The moral is obvious: Why gamble with guesses on gear life (or other critical parts), when it's so easy to be *sure*.

If you want to know more about Ampco Metal, call in your Ampco field engineer. Write for Bulletin 33.

Ampco Metal, Inc., Dept. MP-2, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, California)

AMPCO® METAL *The metal without an equal*

Heating at High Speed . . .

(See article on p. 79)

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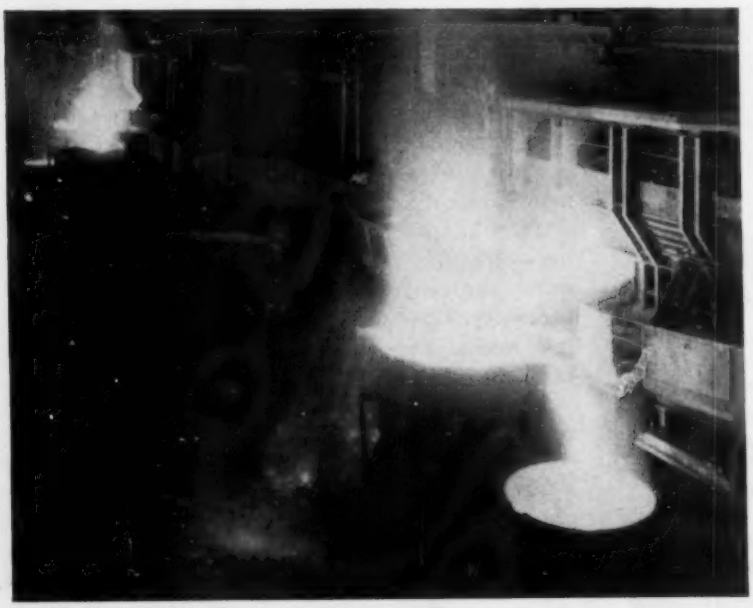
21. "Rapid Radiant Heating of Die Blocks", *Industrial Heating*, November 1955.



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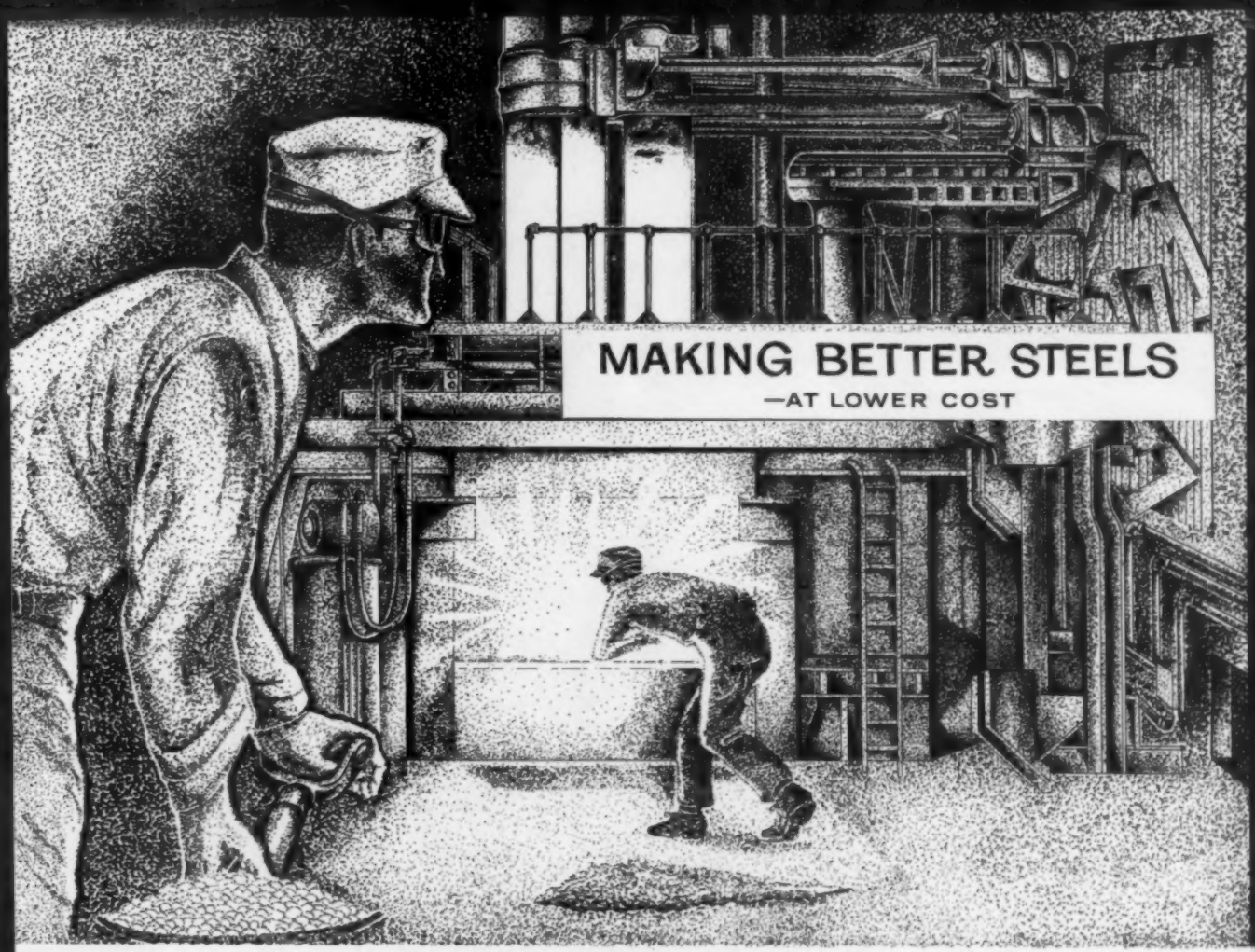

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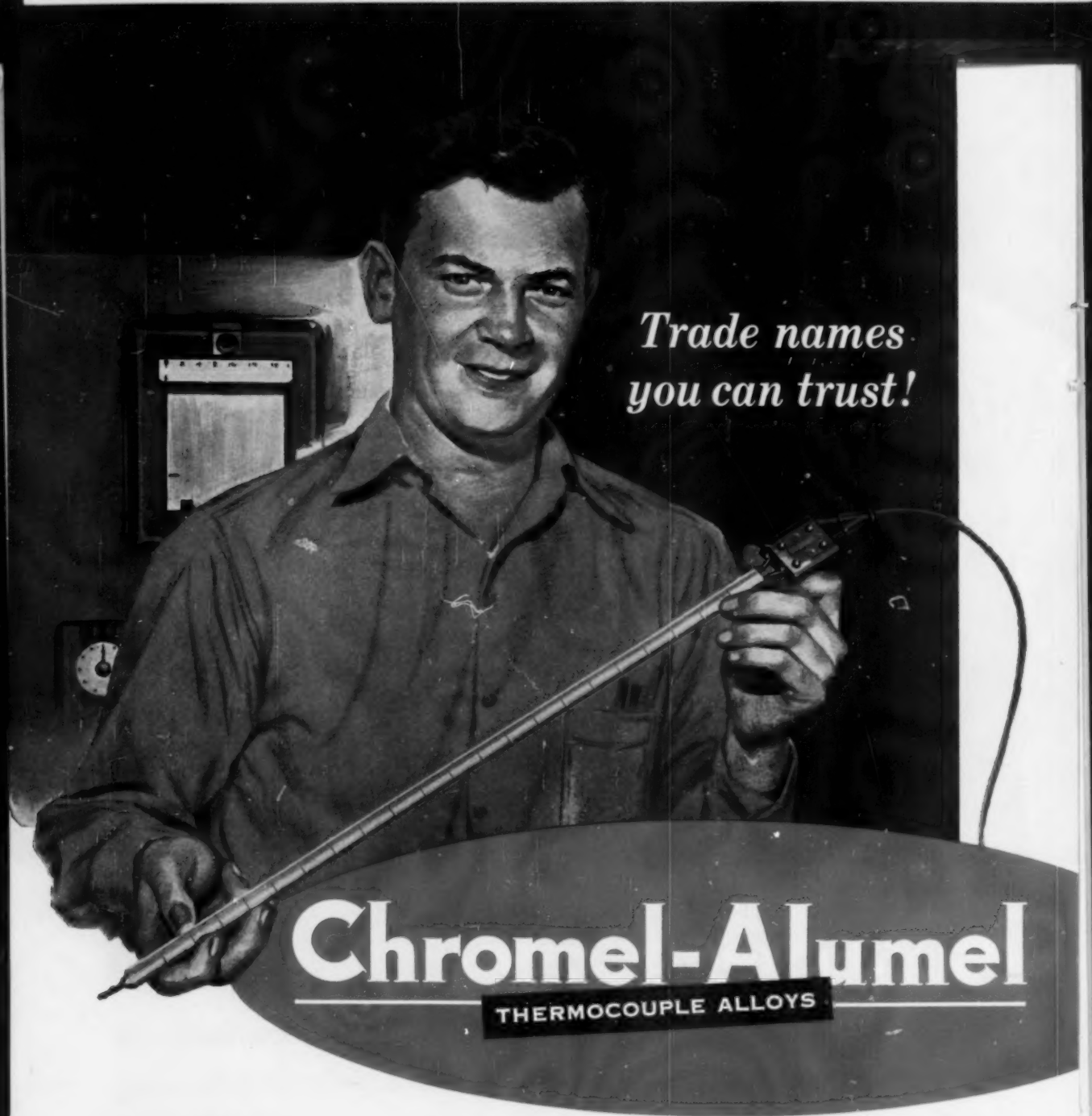

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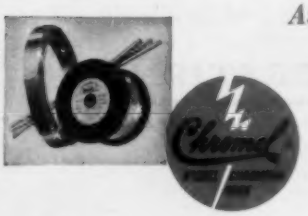

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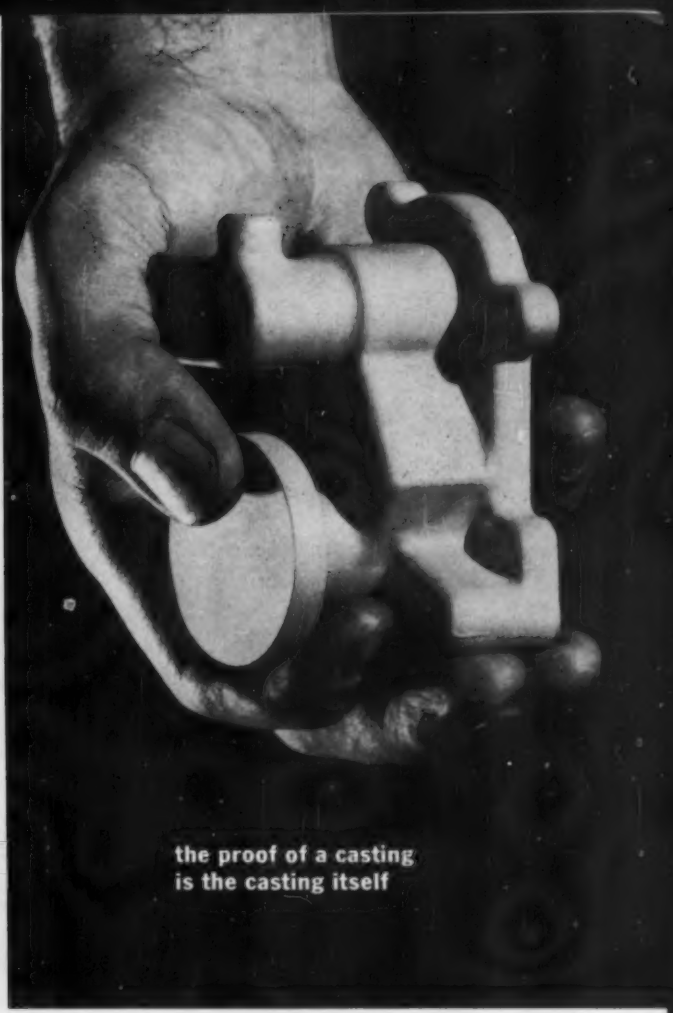

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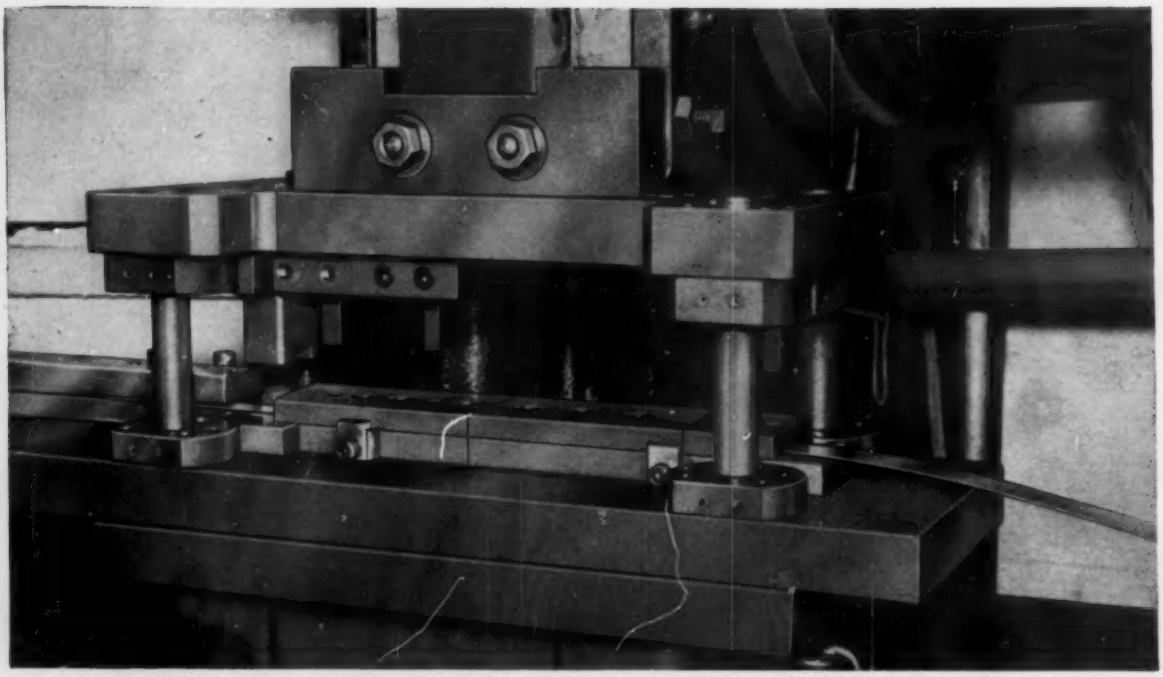

"Tri-Mo" punching and cut-off die used by Warner Mfg. Corp. to form Stainless Steel window tracks

No Resharpening After 1½ Million Pieces With "Tri-Mo" Punching & Cut-Off Die

Warner "Weather-Master" combination window

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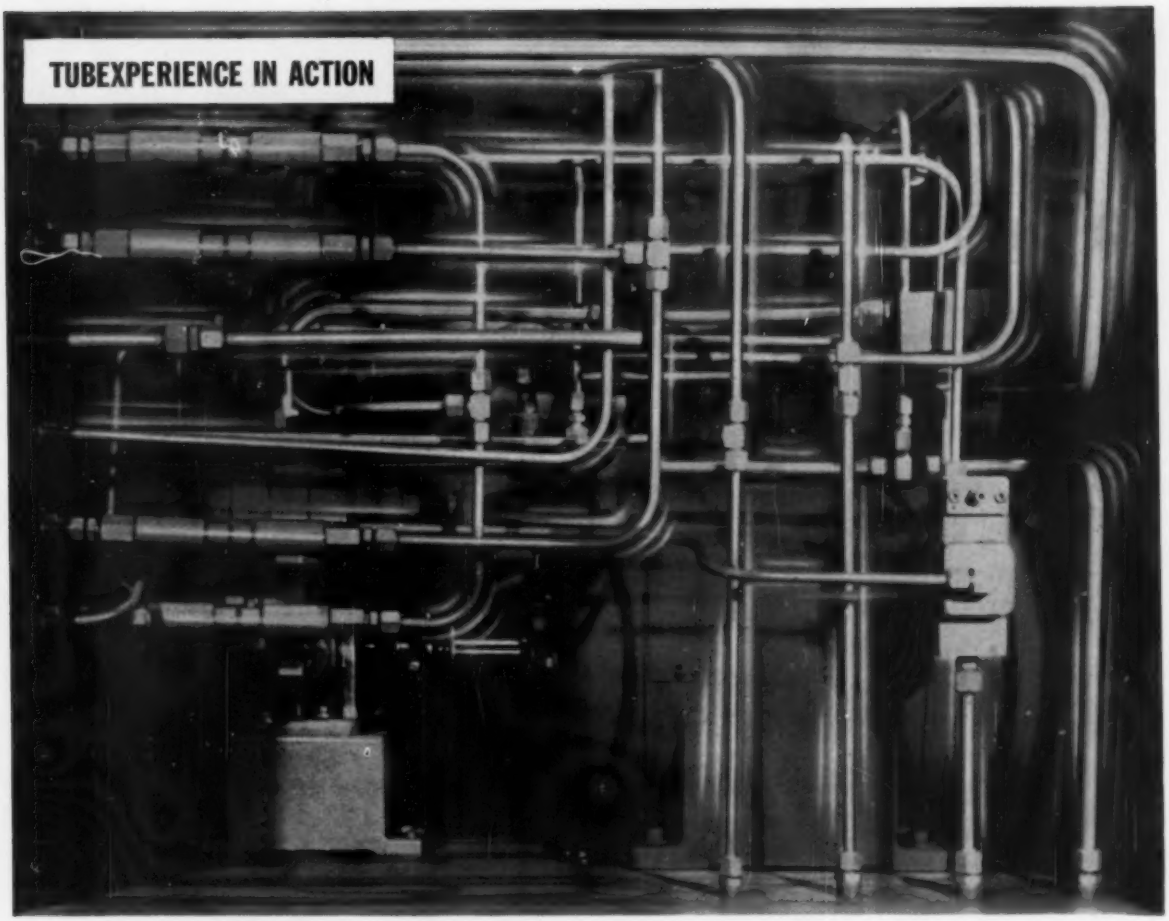

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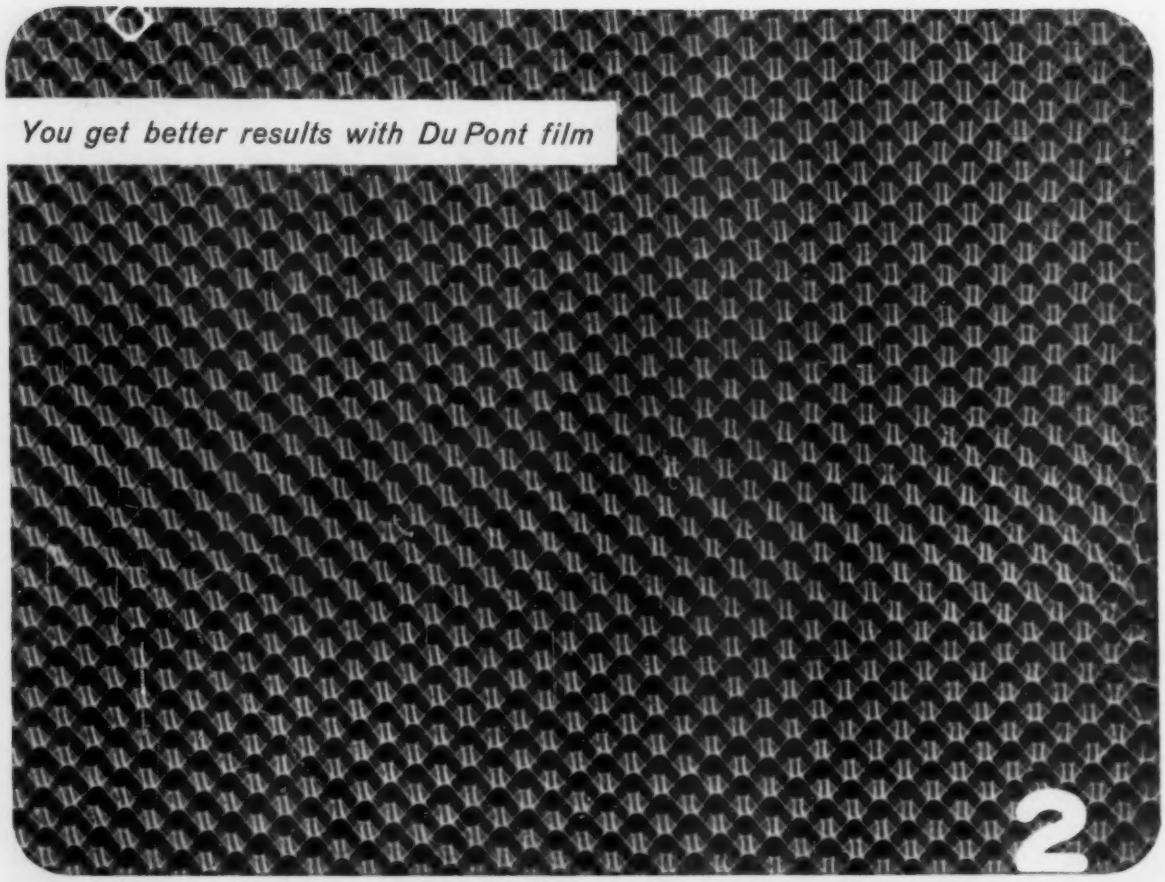

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By Anton deS. Brasunas
Director, ASM Metals
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Dr. Walter L. Finlay
Vice President and
Manager of Research
Rem-Cru Titanium, Inc.

Dr. Finlay, a noted authority on titanium, is the organizer of this new home study course on Titanium. In 1936 he graduated from Lehigh University with a B.S. in Chemical Engineering and was immediately employed by the Remington Arms Company as a Chemical Engineer. In 1938 he was appointed Supervisor of Chemical and Metallurgical Research for Remington.

In 1947 he received a Master's Degree and in 1948 a Doctor's Degree in Metallurgical Engineering from Yale University. Upon formation of Rem-Cru Titanium, Inc., in 1951, Dr. Finlay was appointed Research Manager. In 1954 he was elected Vice President and Manager of Research in which position he continues at the present time.

Aside from his splendid editorial direction, Dr. Finlay has personally planned and written Lesson 1: Titanium, Newest Tonnage Structural Metal—a description of characteristics of titanium, its properties and applications; Lesson 3: Broad Survey of All Titanium-Base Alloys—gives the ABC's of titanium alloys, their structure, heat treatment; Lesson 8: Melting, Casting and Powder Metallurgy—a lesson on the metallurgy of titanium.

Mr. R. L. Powell, Supervisor
Process Research Division
Titanium Metals Corp. of America

Mr. Powell, in Lesson 2: Extractive Metallurgy of Titanium, gives an interesting account of the historical background of titanium. He also covers production from titanium dioxide—production from halides—sponge titanium and producers of titanium.

Dr. Robert I. Jaffee, Chief
Nonferrous Physical Metallurgy Div.
Battelle Memorial Institute.

Lesson 4, Physical Metallurgy of Titanium Alloys, is contributed by Dr. Jaffee. He describes the important alloying elements and major contaminants. Dr. Jaffee is also the author of Lesson 5: Beta Transformation, Heat Treatment, and Thermal Stability of Titanium Alloys.

Mr. D. R. Luster, Chief
Supervisor, Research Dept.
Rem-Cru Titanium, Inc.

Mr. Luster offers Lesson 6: Physical and Mechanical Properties of Titanium. This lesson includes testing, cold work, heat treatment, fatigue, endurance and other properties. Mr. Luster also writes a discussion of the metallurgy of titanium in Lesson 7: Mechanical Metallurgy—effects of strain rate, temperature, notch acuity on standard and experimental grades.

Dr. Lee S. Busch
Director of Research
Mallory-Sharon Titanium Corp.

Richard J. McClintick
Mallory-Sharon Titanium Corp.

Dr. Busch and Mr. McClintick combine their knowledge in Lesson 9: Mill Processing. Here the student is instructed in methods, precautions, and general mill practice. Detailed mill processing information is given.

Mr. John P. Catlin
Rem-Cru Titanium, Inc.

In Lesson 10: Machining and Grinding, Mr. Catlin begins with fundamentals and then moves into drilling, tapping, milling, grinding and other machining operations.

Mr. George C. Kiefer
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Resistance to chemicals, surface conditioning and properties, descaling, chemical analysis and other analyses are expertly written by Mr. Kiefer in Lesson 11: Corrosion Resistance, Surface Conditioning and Chemical Analysis.

Mr. Glen E. Faulkner
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Joining operations in Lesson 12: Joining Titanium and Titanium Alloys, are covered by Mr. Faulkner. Welding, brazing, soldering, and riveting are carefully discussed. Steps in the preparation and aspects of completed joints are included.

Mr. Gordon A. Fairbairn
Supervisor, Materials and Processes
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Design considerations, assembly problems, and applications are unfolded by Mr. Fairbairn in Lesson 13: Titanium Airframe Designs, Manufacture, and Uses. Airframe applications, bending, forming, and joining are also discussed. Included with this lesson is a valuable appendix by August Bringewald of Republic Aviation.

Mr. M. E. Cieslicki, Supervisor
Materials Control
General Electric Company

The excitement of jet engines is presented in Lesson 14: Titanium Jet Engine Design. Mr. Cieslicki covers engine components, basic thermo-dynamics, thrust and other interesting aspects of jet engine design. He also instructs in materials testing.

Mr. W. Stuart Lyman
Titanium Metals Laboratory

Mr. E. W. Cawthorne
Titanium Metals Laboratory

Mr. Lyman and Mr. Cawthorne work together in the final Lesson 15: Latest Development and Trends in Titanium Technology. Here are presented up-to-the-minute developments; also, a look ahead to see what the future holds in store for titanium.

These are the men who have written *Titanium . . . the Metal, Its Alloys and Their Uses*. These are the men who ***know*** titanium. Their thorough knowledge can be ***yours*** . . . to learn in your home . . . at your own pace . . . with help and guidance from ASM Metals Engineering Institute. It would be a great pleasure for me to work with you . . . to help you in every step up the ladder of titanium know-how. Your future in titanium is no further away than the nearest mail box.

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All fifteen lessons in the Titanium course were reviewed by Prof. Joseph W. Spretnak, Department of Metallurgy, Ohio State University, Columbus, Ohio.

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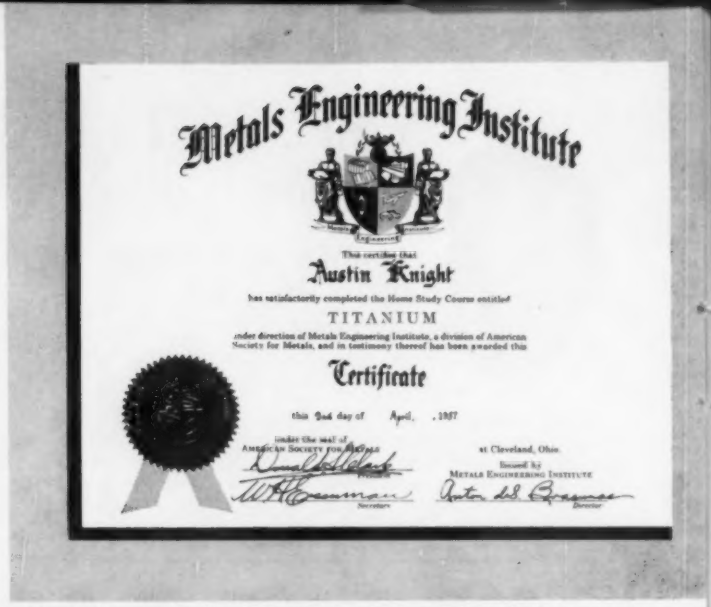
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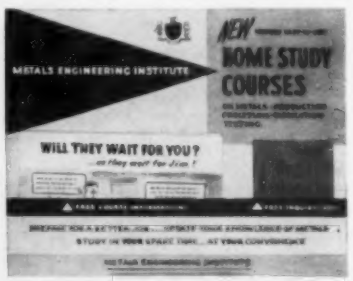

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P.O. Box 4238
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MEMPHIS, TENN.
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F. G. Donofrio
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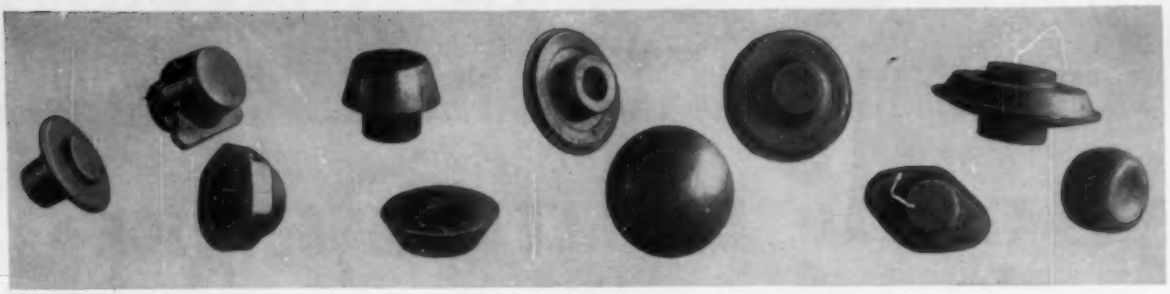
405 WEST FIRST STREET **BOSTON, MASS.**

"OLDEST AND LARGEST EXCLUSIVE MFRS. OF HEAT & CORROSION RESISTANT CASTINGS"

GA ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite

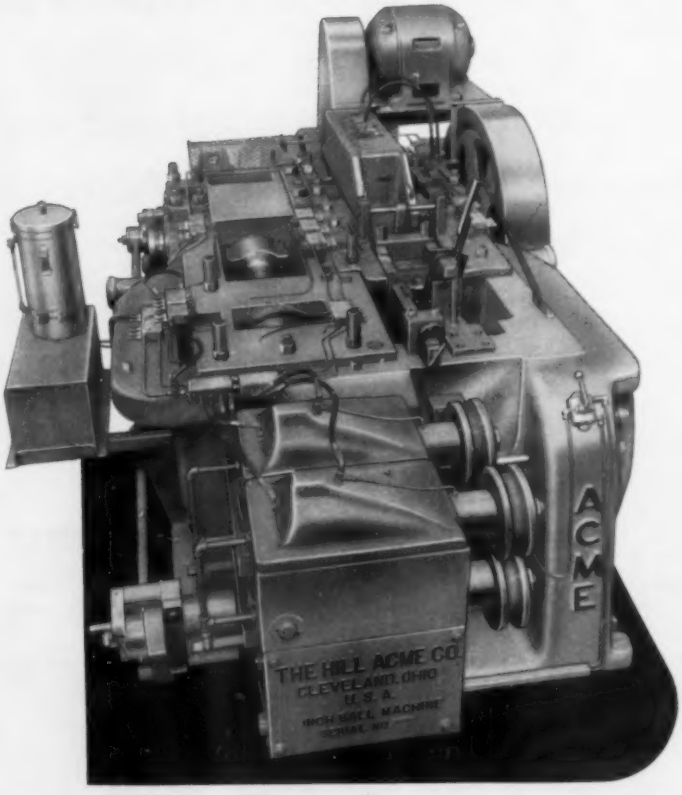


Typical Shapes Produced by ACME Single Blow Forging Machines

SINGLE BLOW FORGINGS
AT 135 PER MINUTE

One man operating this ACME single blow solid die forging machine is producing 135 one inch hard steel balls per minute from 11/16" stock. Automatic feed rolls carry bar stock at proper speed for maximum efficient operation. Adequate safety devices prevent jamming of the die.

ACME solid die forging machines are rated according to the size ball they will forge. Machines are built from 1" to 5" capacity.



Complete information is given in Bulletin SB-57.

The HILL ACME Company

1207 W. 65th STREET • CLEVELAND 2, OHIO

HILL ACME TOOLS FOR INDUSTRY

Manufacturers of: **"ACME" FORGING • THREADING • TAPPING MACHINES • "CANTON" ALLIGATOR SHEARS • BAR-BILLET SHEARS "HILL" GRINDING & POLISHING MACHINES • HYDRAULIC SURFACE GRINDERS • "CLEVELAND" KNIVES • SHEAR BLADES**

Exclusive with the Heroult:

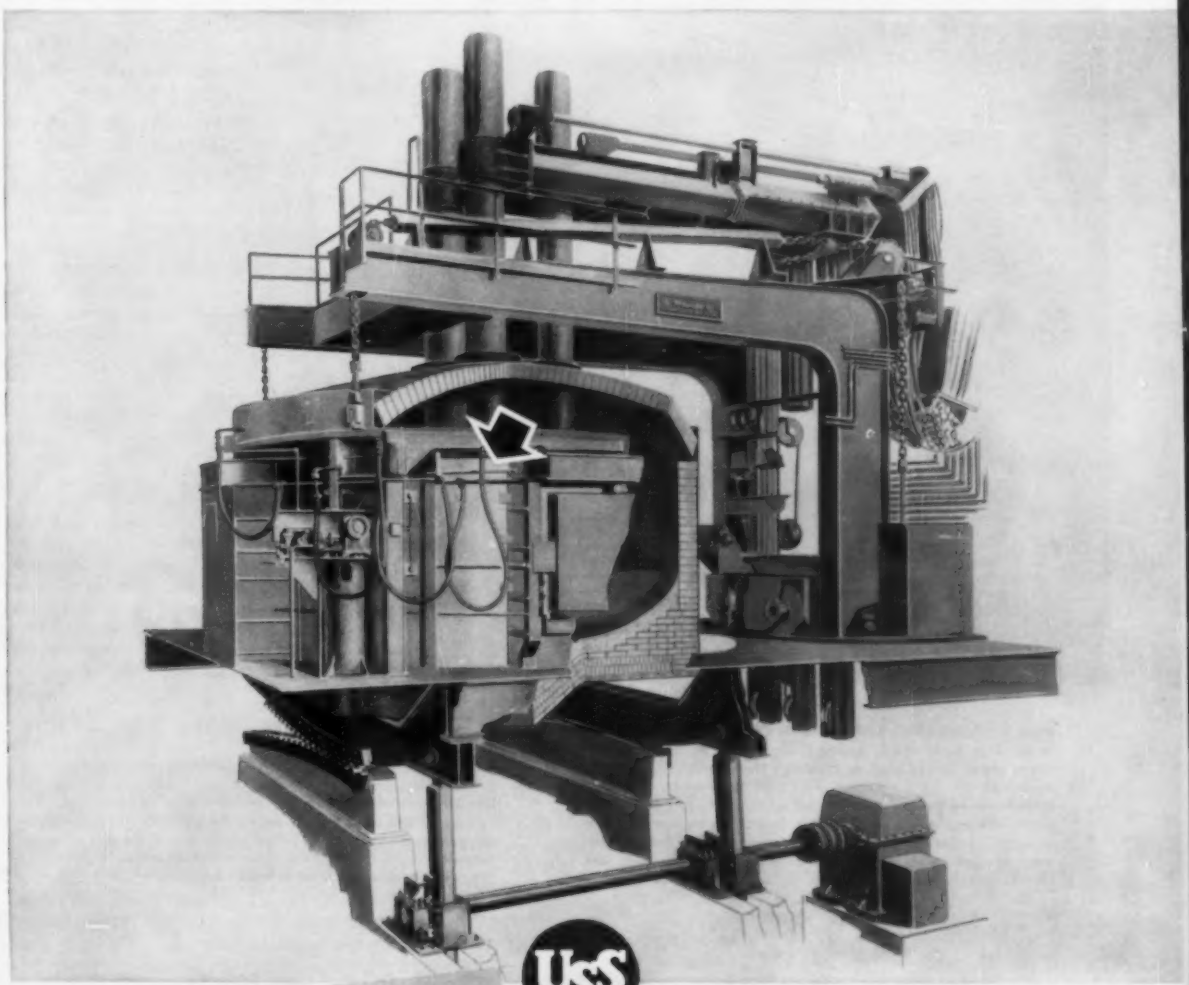
Cage-Type Shell Construction

The Heroult is the only electric furnace on the market with a cage-type shell. In this exclusive design, the shell plates are loosely attached to a heavy structural supporting cage, which allows the plates to expand and contract freely, thus minimizing shell distortion due to extreme changes in temperature. This type of construction also permits easy replacement of damaged shell plates.

This cage-type shell construction is just one of the many advantages you get in the Heroult—advantages which make for performance efficiency, operating economy, and low-cost maintenance. Other exclusive features are: 100% mechanical operation; independently supported operating mechanism; flat bottom shell; and skew back roof ring.

The new Heroult Electric Melting Furnaces are available in sizes of shell diameter ranging from 7′ 0″ up, and with capacities of from 6,000 lbs. up to 400,000 lbs. and greater. They can readily be furnished with a non-magnetic shell bottom section to accommodate induction-stirring equipment. Gantry-type top-charge furnaces, door-charge furnaces, and special furnaces for duplexing and non-ferrous melting can also be supplied.

We welcome an opportunity to help you select and install the Heroult best suited to your requirements. An inquiry to the nearest office will bring complete details.



Heroult
ELECTRIC MELTING FURNACES

AMERICAN BRIDGE DIVISION
UNITED STATES STEEL CORPORATION, GENERAL OFFICES:
525 WILLIAM PENN PLACE, PITTSBURGH, PA.
Contracting Offices in New York, Philadelphia, Chicago, San Francisco and other principal cities.
United States Steel Export Company, New York

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL

"Excellent Results Have Proved the Value and Versatility of Park's Non-Burning Carburizing Compounds"

Says L. A. Lindberg

President, Lindberg Steel Treating Co.
Chicago — Rochester — St. Louis
Los Angeles

"We have had excellent results with this Non-Burning Carburizing Compound for many years. For example, the pinion gear shaft that Milt Vandenberg is looking over has a heat treat specification of .040-.050" case depth and Rockwell 59-62 "C" Scale hardness.

"We process production quantities of these shafts in a two row, automatically controlled, pusher-type furnace using Park's Non-Burning (grade W) Carburizing Compound. The compound supports the parts during carburizing so that distortion is controlled and straightening operations are minimized. Tooth form and lead angle of the gear remain within the allowable tolerance and case depth is very accurately controlled.

"The value and versatility of this operation for such parts as well as for low-cost production items has been proved to us over the years. We have learned to depend on Park for uniformity and for service!"

Park NON-BURNING CARBURIZING COMPOUND is available in sizes No. 3, 6, and 8, and in two grades: "B" and "W". The latter grade is designed to minimize the possibility of copper migration on copper plated work. All sizes and grades are manufactured by coking a special quality coal in the presence of the energizing chemicals. This process produces a homogeneous compound and insures uniform carburizing activity even though usage reduces the material to pinhead size. Shrinkage rates are low and carburizing activity can be maintained indefinitely with addition ratios of as low as 1 to 10.

NON-BURNING is the quality carburizing compound that is economical to use. In addition to its uniformity and low replenishment requirement, it does not burn after removal from the furnace. NON-BURNING is especially suitable for carburizing alloy steel parts such as gears which are direct quenched or reheated. Send for the free, informative technical bulletin B-1, "Pack Carburizing of Steel in Solid Compounds".

● ● ●

Woodside Rapid Carburizers (Non-Burning—Charcoal-Coke-Specification) ● Park-Kase Liquid Carburizers ● Quenching and Tempering Oils ● Cyanide Mixtures ● Neutral Salt Baths ● High Speed Steel Hardening Salts ● Iso-Thermal Quenching and Tempering Salts ● Protective Coatings (No-Carb—No-Kase—No-Scale—No-Tride) ● Carbon Products (Charcoal-Crushed Coke-Pitch Coke-Lead Pot Carbon) ● Kold Grip Polishing Wheel Cement ● Par-Kem Metal Cleaners ● Cutting and Grinding Compounds (Kem-Cut—Kem-Grind—Blue Ice)

Park

PARK CHEMICAL COMPANY ● **8074 Military Ave. Detroit 4, Mich.**

No matter which *FINISH* you like—you can buy it in

MicroRold® QUALITY STAINLESS STEEL

2D—A silvery white, but non-lustrous, surface produced by annealing and pickling cold reduced material. Steel sheets & strip in this condition are most ductile and the surface holds lubricant well for severe drawing operations.

2B—Steel in the 2D condition which is subsequently rolled on a "skin pass" or temper mill. The surface acquires a bright finish from the polished rolls. This surface is somewhat more dense and hard than 2D and is a better starting surface for later finishing and buffing operations.

No. 3—This surface is made by grinding with a No. 100 abrasive. This surface is smooth but not as reflective as 2B.

No. 4—A finer finish than No. 3 made by grinding with a No. 150 abrasive. Like No. 3, this surface is easily blended with hand grinders after forming, drawing or welding.

No. 7—Good reflectivity and brilliance made by polishing with a No. 400 abrasive. This semi-mirror finish must be protected during fabrication by adhesive paper or strippable plastics lest the finish be marred beyond repair.

BRIGHT—A highly reflective surface made by cold reducing with highly polished, glass-hard rolls. This finish is only available in Type 430 stainless.

These are our standard surface finishes that are available in types 201, 202, 301, 302, 304 and 430 except Bright which is type 430 exclusively.

These finishes are regularly supplied in sheet and coil form in widths up to 48 inches.

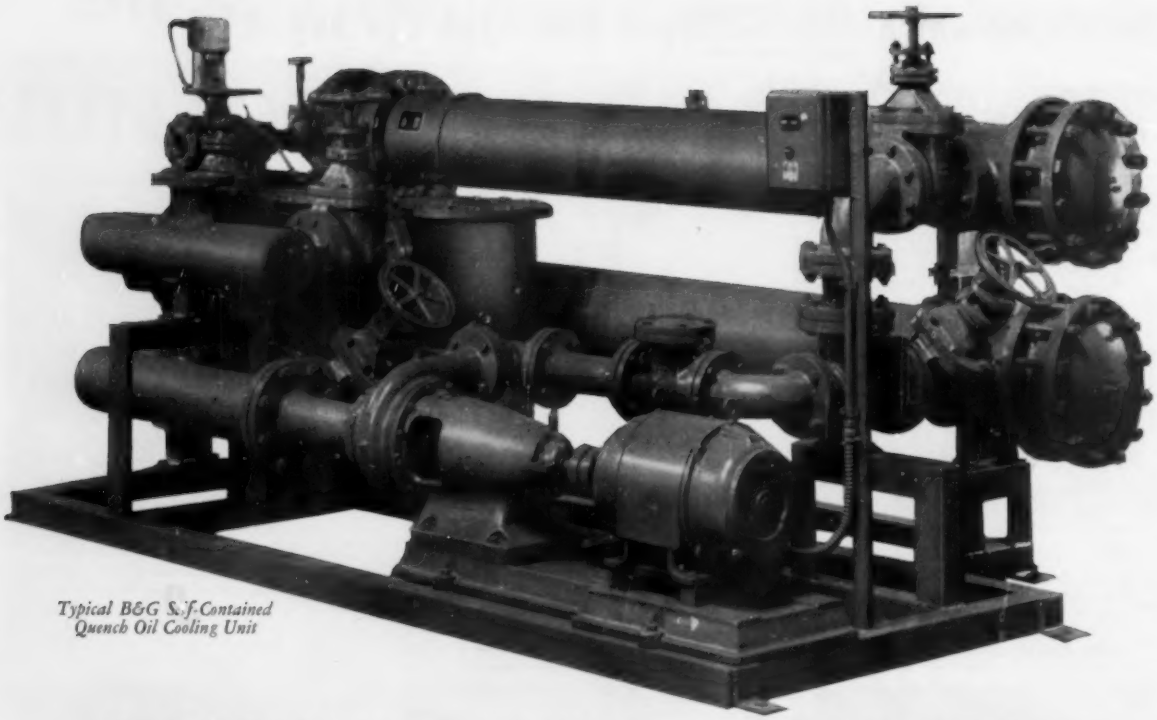
Since Nos. 3, 4, 7 and 430 Bright are smooth reflective surfaces, they are not recommended for severe drawing without special precautions as the mill finish may be marred. Applications such as dairy machinery, kitchen and restaurant equipment and architectural decorative work require only local forming, so these highly polished surfaces are not greatly disturbed. All mill polished sheets are carefully packed to avoid handling imperfections. Protective adhesive paper can be specified by the buyer when needed.

For specific information on recommended surface characteristics for a particular stainless steel sheet and strip application, address your request to our Product Development Dept.

Washington Steel *Corporation*

Producers of Stainless Sheet and Strip Exclusively

2-T WOODLAND AVENUE, WASHINGTON, PA.



Typical B&G Self-Contained Quench Oil Cooling Unit

Complete in every detail for

Controlled

QUENCH OIL COOLING

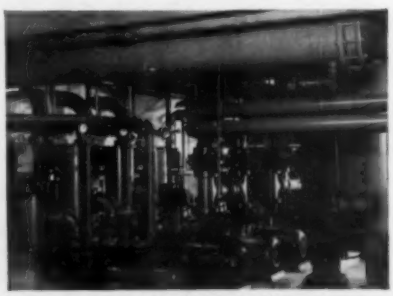
Proper control of quench oil temperature is the certain way to maintain uniform quality in heat-treated metals and to avoid excessive sub-standard rejects. The only question is how to provide that control in the most practical, efficient manner.

While the individual components of an oil cooling installation can be purchased and assembled on the job, the trend today is to install completely factory-assembled oil cooling systems.

To meet this demand, B&G offers completely self-contained oil cooling units—integrated in every respect—ready for immediate operation. These units are engineered to your specific requirements.

Whether your heat treating volume is large or small, the services of the B&G engineering department are available. Your request for information will receive prompt attention.

Every piece uniform in quality because uniformly quenched



Battery of B&G Quench Oil Coolers

B&G QUENCH TANKS

Properly designed to induce maximum turbulence in the quench oil. B&G Quench Tanks are available in standard models or can be built to meet any specific quenching requirement.

●

Send for this combined Catalog and simplified Selection Manual for B&G Self-Contained Quench Oil Coolers

Hydro-Flo* **OIL QUENCHING SYSTEMS**

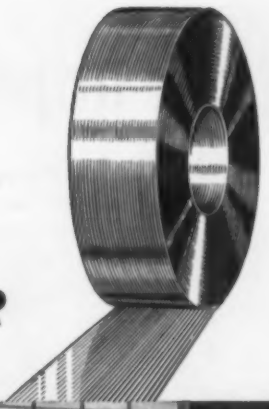
BELL & GOSSETT COMPANY

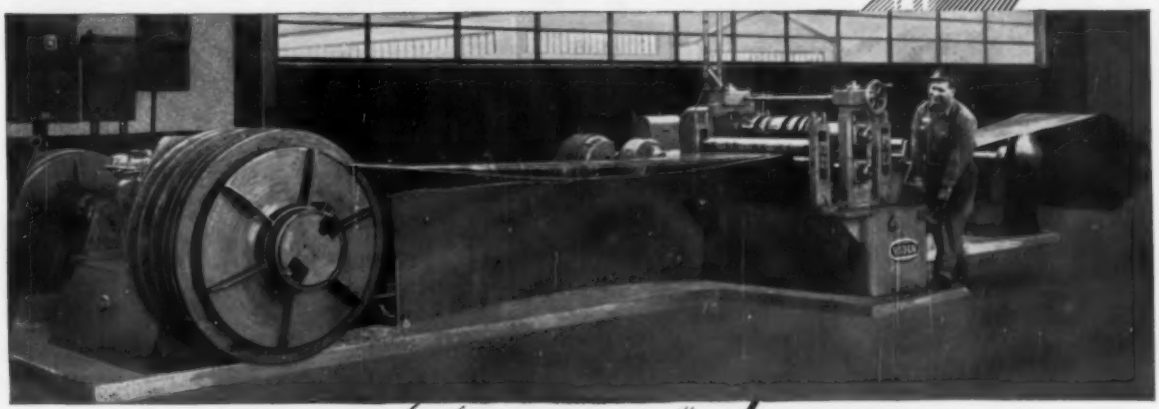
Dept. FD-16, Morton Grove, Illinois

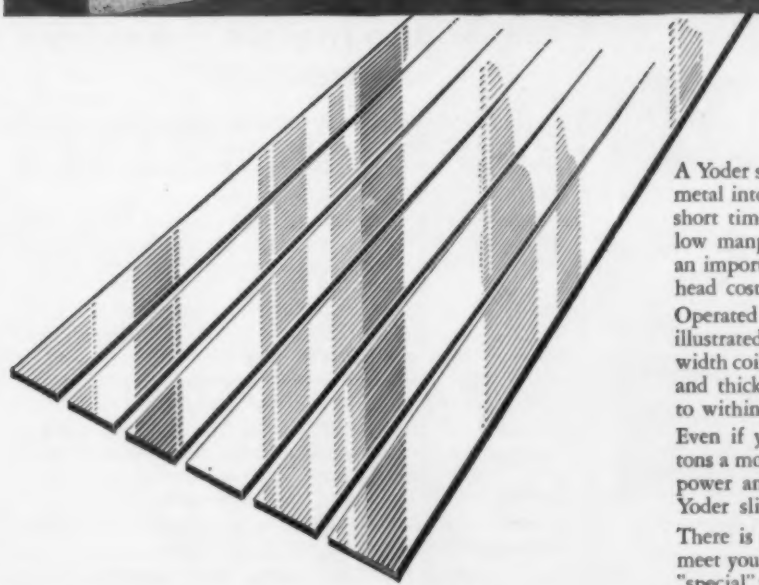
Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, W. Toronto.

*Reg. U.S. Pat. Off.

from cold strip to slit strands
IN SECONDS...
with a YODER
ROTARY MULTIPLE SLITTER







A Yoder slitter converts mill-width coils of flat-rolled metal into many variable-width strands in amazingly short time. Speed, coupled with great accuracy and low manpower requirements, makes a Yoder slitter an important factor in keeping production and overhead costs down.

Operated by only two men, the Yoder Type 3-48 slitter illustrated is designed to accommodate standard mill-width coils up to 48 inches wide, in a variety of metals and thicknesses. The slit strand widths can be held to within a .004" tolerance.

Even if your steel requirements are as little as 100 tons a month, the savings to be realized in time, manpower and raw material costs alone will pay for a Yoder slitter in the first few months of operation.

There is a Yoder slitter designed and engineered to meet your requirements, and to speed the delivery of "special" width stock in a wide range of large or small sizes. Send for your free copy of the fully-illustrated, 76-page booklet, "Multiple Rotary Slitting Lines."

THE YODER COMPANY
5595 Walworth Avenue • Cleveland 2, Ohio

ENGINEERING **YODER** MANUFACTURING

ROTARY SLITTING LINES
PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES

BARBER COLMAN

Impressor

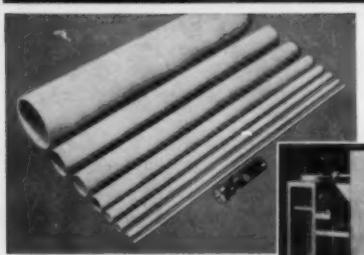
for quick, on-the-spot hardness testing of non-ferrous metals and plastics

Simple to operate . . . gives an instant, dependable measure of hardness. Operates on principle of forcing a spring-loaded indenter into the surface with the amount of penetration registering on a dial indicator. Can be used in any position . . . tamperproof . . . compact . . . rugged, yet weighs only 12 oz. Thousands used by industry.

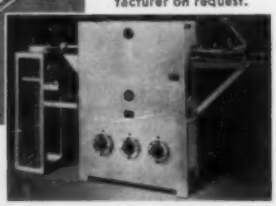
Write today for complete details.

BARBER-COLMAN COMPANY, Dept. B, 1218 Rock St., ROCKFORD, Illinois

McDANEL



Furnace equipped with McDanel Zirco Tube, 46" long, 1½" I.D., 1¾" O.D. Operates at temperatures from 1,650 to 3000° F. Name of manufacturer on request.



Protection Tubes Help Produce Controlled Atmosphere at 3,000° F. In Research Electric Furnace

Experimental sintering, brazing, and heat treating experiments are conducted in this well known laboratory tube furnace, equipped with McDanel Zirco Protection Tube, open at both ends. Sample is heated and cooled within gas-tight tube permitting use of special atmospheres. McDanel Protection Tubes have high resistance to thermal shock and low coefficient of expansion. Special sizes.

McDANEL Industrial CERAMICS

McDANEL REFRACTORY PORCELAIN COMPANY BEAVER FALLS, PENNA.

Send Today for Bulletin P1-55

WHAT'S NEW AT BRISTOL . . .

Photo courtesy General Thomas J. Rodman Laboratory, Watertown (Mass.) Arsenal.

NEW!

Immersion thermocouple for molten metals measures to 3200 F

The new Bristol portable immersion-type thermocouple is designed for direct measurements in melts of both ferrous and non-ferrous metals. Simplicity and operating economy are its key features.

Rugged tubes give economy. Latest result of Bristol's continuous development program in instruments and accessories for pyrometry, the new thermocouple's durable protection tube can take up to 14 dips in molten steel at 2700 F to 3200 F. Metals of lower melting temperatures such as brass and aluminum will give far longer life. What's more, replacement of the protection tube, plus reasonable care, allows re-use of the platinum sensing element—most expensive part of the unit.

Standard and "high-speed" models. The standard model of the new thermocouple—full response 30-45 seconds—features a Bristol metal-ceramic (LT-1) secondary protection tube. A special "high-speed" model—response 15-20 seconds—has a single quartz protection tube with quick-change thumbscrew, designed for easy replacement.

STOCK PARTS CUT COSTS, SPEED SERVICE

All parts in the new molten metal thermocouple are stock parts—a product of Bristol's careful design and advanced manufacturing methods. Result: lower first cost due to production economies and faster delivery on replacement parts.

Write today for complete data on this outstanding Bristol contribution to instrumentation in metallurgy. The Bristol Company, 155 Bristol Road, Waterbury 20, Connecticut.

7.1

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

BRIDGEPORT BRASS COMPANY

Welds Aluminum Tubing at speeds up to

120 fpm

with an

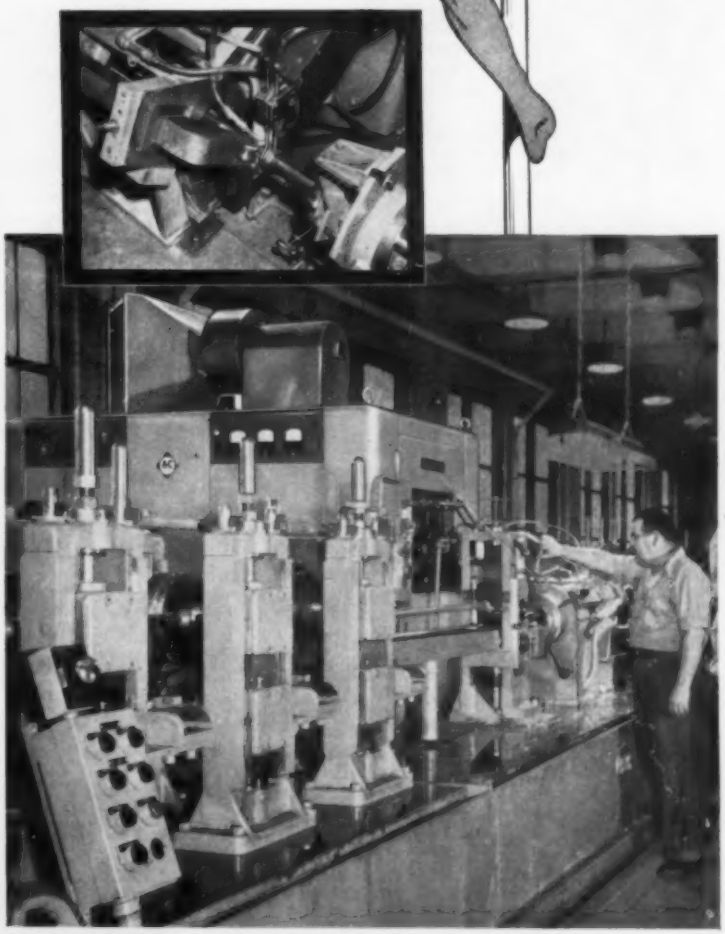
Allis-Chalmers Induction Heater

MR. HI FREQUENCY and the Allis-Chalmers induction heater solved an important production problem and gave Bridgeport Brass tremendous welding speed. Because aluminum has an abrupt melting point and a tendency to buckle, conventional arc welding yielded but a few feet per minute. By *confining* heat to a thin surface layer at the contacting edges of the formed tubing, Allis-Chalmers induction heating produced amazingly good results where previous methods failed.

Why Allis-Chalmers

Allis-Chalmers enhances induction heating's inherent speed with properly designed work handling equipment. An automatic timer and output controls, standard on Allis-Chalmers units, promote precision operation. Extensive laboratory facilities, unparalleled application experience, factory supervised installation and service assure complete dependability.

If you braze, solder, harden, anneal or heat for forging or melting, it will pay you to get all the facts on Allis-Chalmers induction heaters. See your nearby Allis-Chalmers representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.



Heart of Bridgeport's integrated mill is a 50-kw Allis-Chalmers induction heater. Coil is interchangeable to accommodate various tube sizes.

A-C ALLIS-CHALMERS

A-5456

ALLIS-CHALMERS

Sheffield's CAVITRON

Machines the hardest materials

Such as:
- Hardened Tool Steel
- Cemented Carbides
- Cermets and Ceramics
- Ferrite
- Germanium
- Aluminum Oxide
- Jewel Stones

End Products are
- Dies
- Transistor Components
- Tire Molds
- Electronic Elements
- Machine Parts
- Jewel Bearings
- And Many Others

Get full information on the spectacular economy and precision of the Cavitron—Write to The Sheffield Corporation, Dayton 1, Ohio, U.S.A., Dept 39.

the SHEFFIELD corporation
of Bendix Aviation

manufacture and measurement for mankind

7759

NOW AVAILABLE . . .
BASIC METALLURGY—VOLUME II

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- PYROMETRY
- HEAT TREATING EQUIPMENT
- PREPARED ATMOSPHERES FOR HEAT TREATMENT
- CORROSION TESTING
- MISCELLANEOUS TESTING

Written by Members of the Philadelphia Chapter
American Society for Metals
Edited by G. William Zuspan
Assistant Professor of Metallurgical Engineering
Drexel Institute of Technology

ASM Technical and Engineering Book Information Service
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Enclosed please find $..... for..... copy(s) of Basic Metallurgy, Volume II.

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HARROP ELECTRIC FURNACES
meet your size, temperature and operating requirements

Compact NMR-12 model (at right) is designed for continuous, heavy service at temperatures to 2800°F. It will conserve floor space in your laboratory or shop . . . cut operating expense . . . speed testing or production.

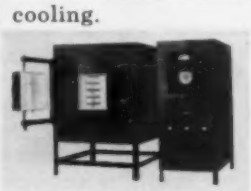
Specifications NMR-12 Setting space 12″ wide x 14″ high x 17″ deep. 3000° F. internal refractories. External blower for accelerated cooling. Transformer capacity 15 KVA at 110 volts, 30 KVA at 220 volts on the secondary. Can be equipped for any standard voltages, phases and frequencies.

Instrumentation: Optional, for simple temperature control, repetitive heating to any preselected temperature with or without adjustable holding time, or with complete program control.

Standard Harrop furnace models cover setting spaces from 7″ x 7″ x 9″ to 36″ x 36″ x 40″.

Special furnace applications demanding an unusual shape or size of firing chamber, variation in door opening, temperature range or other specific requirements will be designed and built by Harrop. Depend on Harrop's years of experience and engineering knowledge to solve your particular furnace problem quickly and economically.

Standard NMR-20 model (pictured below) 20″x 20″x 24″ setting space, temperature range to 2800°F, silicon carbide resistor heating elements, blower for accelerated cooling.



Standard instrumentation includes program controller, 6 tap switches and selector switch for manual or instrument control and blower cooling. Instrumentation can be varied to meet any requirement.

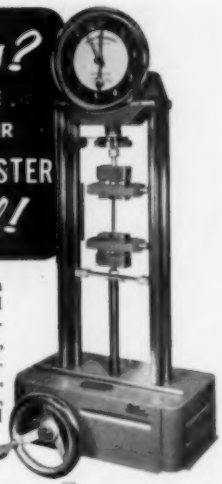
For non-obligating recommendation on the furnace for your particular need, send information on materials, temperature range, heat control and firing objectives to: Dr. Robert A. Schoenlaub, Technical Advisor.

HARROP ELECTRIC FURNACE DIVISION OF
Harrop Ceramic Service Co.
Dept. M. 3470 E. Fifth Ave.
Columbus 19, Ohio

Testing Problems?

• TENSILE • TRANSVERSE
• COMPRESSION • SHEAR

A DILLON UNIVERSAL TESTER will solve them all!



You can make *any* workbench a testing area with a DILLON Model L Bench Tester. This low cost instrument precision-checks metal, plastics, wire, rubber, springs, etc. Operates in tensile, compression, transverse or shear! Handles round, flat or special shapes. Hand wheel or motorized. Equipped with max. indicator. 7 interchangeable gauges. For materials up to 125,000 lbs. PSI tensile. Wide range of gripping fixtures. Also available on stand.

MODEL L

MODEL M

FOR EXTREMELY DELICATE MATERIALS
Model M for low strength specimens between 0 & 300 lbs. Meets ASTM & Fed. specs. Pendulum principle. Has 5 scales.

Write TODAY for brochures and LOW price schedule

W.C. Dillon & CO., INC.

14574F Keswick St.
Van Nuys 14, Calif.
(suburb of Los Angeles)

THIS NATIONAL FONTAR® BORESCOPE BRINGS YOUR EYE TO "THE INACCESSIBLE"

Permits bright, close-up inspection within any bore, threaded hole, recess or interior surface. If there is a point of entry .10" diam. or larger, a National Fontar Borescope facilitates critical examination for defects in interiors of aircraft engines, for example, as well as tubing, castings, machined or welded parts. Brightly illuminated vision through this instrument can be provided straight-forward, forward obliquely, at right angle or retrospectively.

The area you might want to inspect may only seem inaccessible. A National Borescope can bring it into bright, sharp vision for you. Use it to minimize rejects, save disassembly costs, for better quality control and lower costs. ★ ★ ★ ★ ★ ★

National

SEND FOR NEW ILLUSTRATED CATALOG.

TERRITORY OPEN
FACTORY AGENTS WANTED

ENGELHARD INDUSTRIES, INC.
NATIONAL ELECTRIC INSTRUMENT DIVISION
92-21 Corona Avenue • Elmhurst, N. Y.
SUPPLIERS TO THE AEC AND MAJOR INDUSTRIALS

Bata cuts mold cleaning time in half with Pangborn Hydro-Finish

Bata Shoe Co., Belcamp, Md., used to clean shoe molds by pickling. For a better cleaning job, Bata replaced this process a year ago with Pangborn Hydro-Finish. Today this machine gives Bata top quality cleaning, does the job *in half the time* required by pickling and has required "no maintenance whatsoever." Also, acid disposal problems have been eliminated.

Says Mr. Albert Kotras, Research, "We thought it was sales talk but the Hydro-Finish has lived up to every claim the Pangborn representative made." Convinced by the performance of its Hydro-Finish machine, Bata management now plans to order a second one.

Today, through new design and use of air jet sluriators, Pangborn Hydro-Finish costs less originally, costs less to maintain and gives you easier handling and added efficiency. Write for Bulletin 1403 to PANGBORN CORP., 1800 Pangborn Blvd., Hagerstown, Md. *Mfrs. of Blast Cleaning and Dust Control Equipment.*

USE PANGBORN HYDRO-FINISH FOR:

Deburring • Surface finishing • Finishing threaded sections • Improving cutting tool life • Maintaining dies and molds • Removing grinding lines • Removing heat treat scale • Preparing surfaces for coatings, platings, etc.

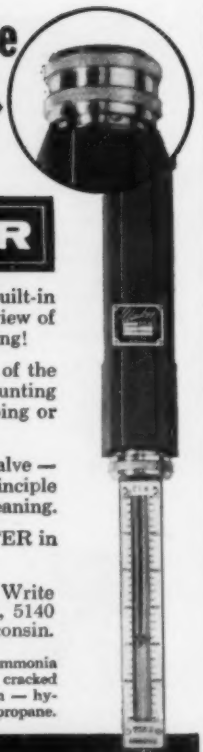
Pangborn

BLAST CLEANS CHEAPER

the meter with the built-in Valve...

Waukee

FLO·METER



With the Waukee FLO-METER'S built-in Valve, you adjust the gas flow in full view of the scale. You can see what you're doing!

The Control Valve is an integral part of the FLO-METER, designed for panel mounting and simple piping No extra valve piping or installation. Saves time and money.

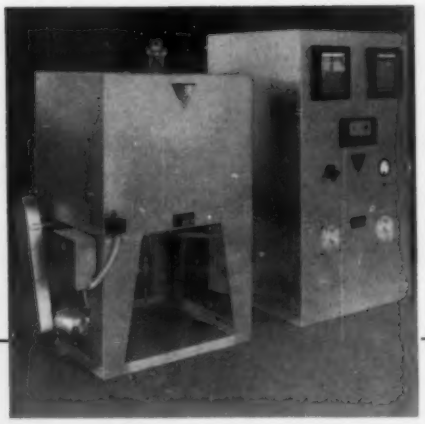
It's a Waukee-designed and built valve — sturdy, simple, smooth. Needle-valve principle for accuracy, sensitivity, and easy cleaning.

And you can still clean the FLO-METER in 5 minutes *or less!*

Complete information in Bulletin 203. Write for it. **Waukee Engineering Company**, 5140 North 35th Street, Milwaukee 9, Wisconsin.

For measuring: air — ammonia — dissociated ammonia — argon — butane — city gas — endothermic cracked — exothermic cracked — forming gas — helium — hydrogen — natural gas — nitrogen — oxygen — propane.

Waukee FLO-METERS • AIR-GAS MIXORS
INDUSTRIAL WASHING MACHINES



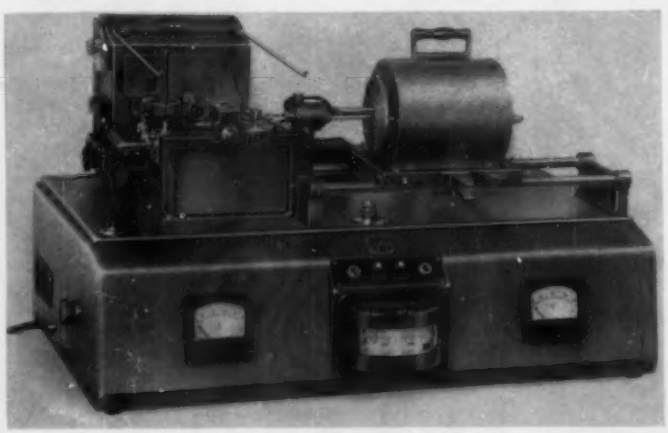
PERECO *motorized*
INVERTED-PIT FURNACE

- **Raise or lower hearth without vibration**
- **Get closer heat gradient to 2750° F.**

Convenience of bottom loading, coupled with close, vibrationless motor control of the elevating equipment, is an important feature of this Pereco Model IPM-74 Electric Furnace. It is only one of a series of similar units offered by Pereco in a range of chamber sizes and a choice of controls for operating temperatures to 2750° F. Ask Pereco for further details on this series of furnaces—as well as other standard or special units for temperatures from 450° to 5000° F.

PERENY EQUIPMENT CO.
Dept. Q, 893 Chambers Rd., Columbus 12, Ohio

DILATOMETERS
SYSTEM BRINKMANN-NETZSCH



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1150° C

1350° C

1550° C

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Fully automatic with program controlled rate of heating and variable recorder speeds.
Prices from $2700.00 complete.

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Simplified dilatometer w/o automatic features, direct reading.
Prices from $980.00

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BRINKMANN HOUSE, GREAT NECK, L. I., NEW YORK

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Triangle RR is a super refractory produced particularly to meet the challenge of the ever increasing high operating temperatures in industry. Its high purity in conjunction with its impervious structure of interlocking corundum crystals makes it very resistant to chemical attack.

Triangle RR pyrometer protection tubes and insulators are highly recommended for use with platinum, platinum-rhodium thermocouples where anyone of the following considerations is important:

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2. **Freedom from attack of rare metals by silica or magnesia**
3. **Longer thermocouple wire life**
4. **When high rhodium content thermocouple wires are used**

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(IF REQUESTED)

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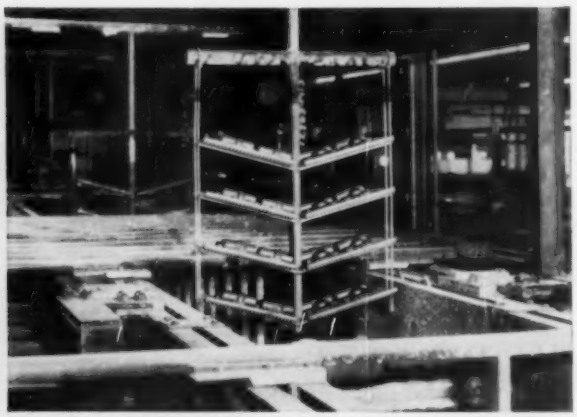
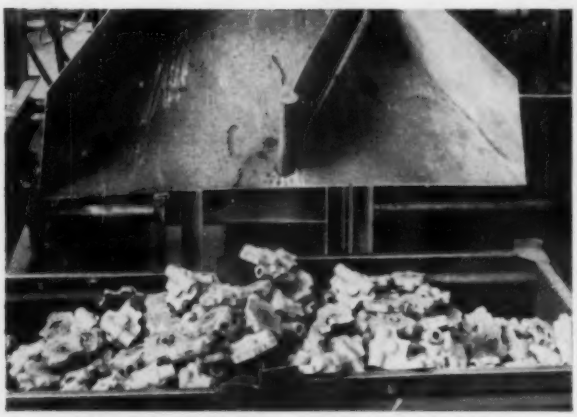


DIRTY CASTINGS COME CLEAN



*Photos, courtesy Ajax Electric Company**

CHEMICALLY CLEAN WITH VIRGO® ELECTROLYTIC SALT

How Eaton Manufacturing saves up to 75% on salt for desanding

A short dip in this new, fully mechanized furnace, and castings come up completely cleaned for the Eaton Manufacturing Company.

Inside the furnace is a new desanding salt—Virgo Electrolytic Salt—which costs as little as one-fourth as much as comparable electrolytic cleaners.

This molten salt takes just 15 to 20 minutes to clean even the hard clinging sand, scale, graphite, and other surface impurities from iron and steel castings.

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No acid dip. The Virgo Electrolytic Salt process requires no acid dip after rinsing. Of course, if other operations require it, you *can* use the acid treatment.

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Samples tested. We have a bath set up in the Hooker laboratories, so you can prove for yourself how Virgo Electrolytic Salt can clean your castings—*for less money*. Write us about submitting samples for such test cleaning.

For technical data on the salt and the process, send us the coupon.

**Designers and builders of mechanized furnace.*

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- ☐ Virgo Descaling Salt
- ☐ Virgo Molten Cleaner
- ☐ Caustic Soda
- ☐ Muriatic Acid
- ☐ NIALK® TRICHLORethylene

Clip and mail to us with your name, title and company address.

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HOOKER ELECTROCHEMICAL COMPANY

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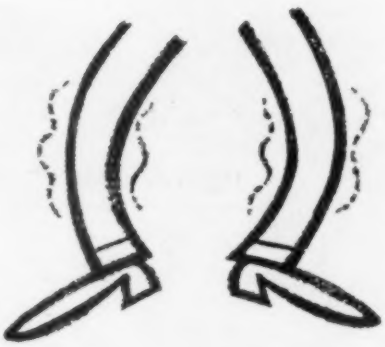
February—Bought lower grade ammonia at a bargain price . . .

Later—Discoloration of finished parts apparent, rejects more frequent, pickling necessary . . .



Still later—Oil! Pressure regulators clogged, catalyst poisoned, incomplete dissociation . . .

Too late—Shut down metal treating line for repairs . . .

Be trouble-free—use only Armour's 99.98% pure ammonia in your metal treating operation!

Such consistent purity, dependable delivery service from 163 stock points and 8 bulk stations—and a technical service that's second to none—make Armour your one best source for trouble-free ammonia. For further information and a copy of the informative Dissociated Ammonia booklet, write us on your company letterhead.

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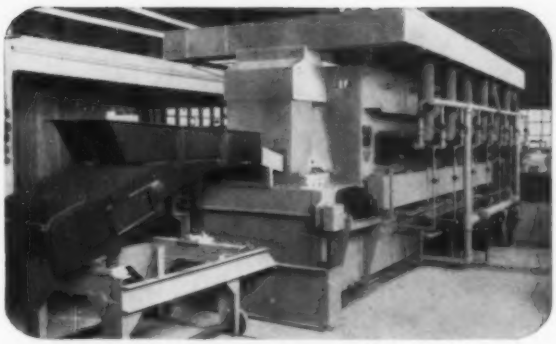

EF gas fired radiant tube gas carburizing unit with automatic quench, wash and draw —conveys gears and other material through on three separate rows of trays.

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for these and other processes

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Salem - Ohio

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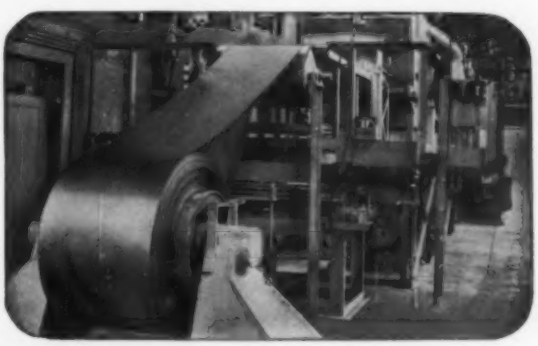
EF continuous equipment is built in many sizes and types for various processes on stainless and other ferrous and non ferrous strip, wire, tubing, stampings and other products.



200 SERIES STAINLESS STEEL PRODUCTION IS REALLY ROLLING–

with ELECTROMET Alloys

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The 200-series stainless steels are the result of basic work carried out at the ELECTROMET Research Laboratories. Stainless steel producers have been granted royalty-free licenses under the patents covering these developments.

For full information contact the nearest ELECTROMET office. Birmingham, Chicago, Cleveland, Detroit, Houston, Los Angeles, Phillipsburg, N. J., Pittsburgh, San Francisco. *In Canada:* Electro Metallurgical Company, Division of Union Carbide Canada Limited, Toronto. ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

Cr-Ni-Mn 200-series stainless steels are becoming increasingly popular for both household and industrial products fabricated from stainless strip. Here the final pass on finishing rolls gives surface finish and hardness to the strip.

The terms "Electromet," "EM," "Mansiloy," "Simplex" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.